• MAKING OLD MACHINES NEW • SELLING TO THE SOVIETS • RAILROAD POWER •

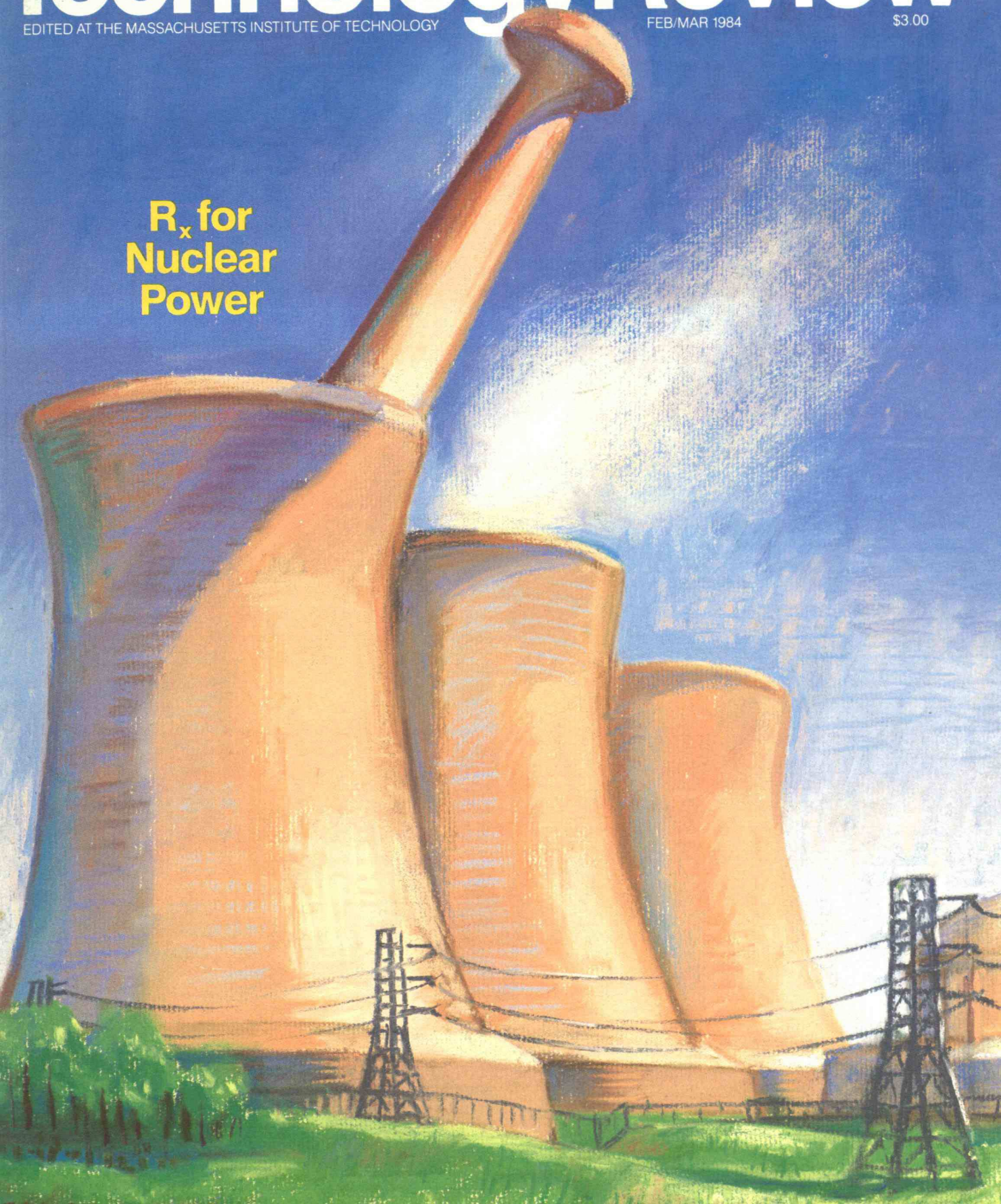
Technology Review

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

FEB/MAR 1984

$3.00

R_x for Nuclear Power



technology
review
Published by MIT

The gasoline-powered range of Mercedes-Benz automobiles for 1984 extends from the 2.3-liter four-cylinder 190E 2.3

For 1984, five of the more potent gasoline-powered automobiles sold in America are sold by Mercedes-Benz.

CHANGING CONDITIONS never seem to catch the engineers of Mercedes-Benz napping.

Diesel cars, years in advance of the efficiency stampede.

Turbodiesels that anticipated a demand for efficiency plus performance. And it should now come as no shock that Mercedes-Benz greets the current performance renaissance with a range of *five* muscular gasoline performance cars.

In fact, gasoline-powered models now represent half the Mercedes-Benz line. Four of them–the 190E 2.3 Sedan, the 380SE Sedan, the 500SEL Sedan and the 500SEC Coupe–are new to America for 1984.

They help form the most vivid group of performance automobiles Mercedes-Benz has ever built for sale.

The most spirited Mercedes-Benz is unquestionably the stunning new 190E 2.3 Sedan "–perhaps the best in the world in its size class," in *Road & Track's* opinion. And perhaps the equal, in pure driving exhilaration, of any sports sedan now sold.

BOLD PERFORMANCE, MUTED NOISE

The 190E combines its trim 2,655 lbs. and a four-cylinder, 2.3-liter fuel-injected engine to reach test track maximums of 115-mph-plus. Yet it is so finely engineered that vibration and noise are as muted as in larger Mercedes-Benz sedans.

Its performance character is underscored by the five-speed manual gearbox that can be ordered as an alternative to the four-speed automatic.

"Transmission designers from around the world," *Road & Track* suggests, "should take a sabbatical to spend time at Stuttgart learning the Mercedes way of building gearboxes."

A V-8 LIKE NO OTHER

The new 380SE Sedan exploits the technology of the eighties to shine as one of the most confidently responsive passenger cars of the eighties.

Turbine-smooth and jackrabbit-quick, its 3.8-liter V-8 engine evolves from a new design generation meant to deftly balance power and efficiency.

Note that its block is even made of a different substance than most V-8's–cast not in iron but in an exotic alloy of aluminum, magnesium and silicon that radically cuts weight. The pistons in this engine move not against metal cylinder walls but against a surface of slippery, smooth, seemingly indestructible silicon crystals.

The 380SE's torque-converter four-speed automatic gearbox is so well integrated with this power plant that it seems to function almost as part of the engine. To the benefit of satisfying performance motoring.

What that 3.8-liter engine does for the 380SE it does for the 380SL Roadster, the two-seater descendant of Mercedes-Benz' immortal SL sports car series, carried over intact for 1984.

*Approximate suggested advertised delivered price at port of entry.

Sedan, at $24,000; to the 5-liter V-8 500 SEC Coupe, at $57,000.* Left to right: 190 E 2.3, 380 SE, 500 SEC, 500 SEL, 380 SL.*

Mercedes-Benz launches two new flagship models for 1984–the 500 SEL Sedan and the 500 SEC Coupe. They top off the gasoline performance line in formidable fashion.

The 500 SEL, featured below, is a five-passenger sedan of near limousine status. The 500 SEC is its sybaritic four-passenger touring coupe counterpart.

Each is propelled by an Olympian performer of an engine: the five-liter, light-alloy Mercedes-Benz V-8, new to America for 1984 but already somewhat of a legend on the highways of Europe.

So massive are its power reserves that, though not a practice recommended for normal driving, it could quietly cruise at 55 mph in *second* gear. At 55 mph in top gear it is turning at a lazy and barely audible 1,886 rpm. Acceleration from zero to 55 mph is jet-smooth. Acceleration from almost any point in the speed range, in any gear, is vivid.

HIGH-PERFORMANCE ENGINEERING

The automobiles powered by these engines are painstakingly engineered to high performance levels, from suspensions to steering to brakes. And to the stern safety standards imposed by Mercedes-Benz on every car it builds.

These five gasoline-powered Mercedes-Benz models for 1984 are meanwhile complemented by five of the most advanced *diesel*-powered automobiles you can buy–each an outstanding performer in its own right. Making for the most varied, the most exciting, the most timely lineup of models Mercedes-Benz has ever sold in America.

Engineered like no other car in the world

NEW KODAMATIC™ TRIMPRINT™ INSTANT COLOR FILM.

KODAK WILL CHANGE YOUR IMAGE OF INSTANT PHOTOGRAPHY.

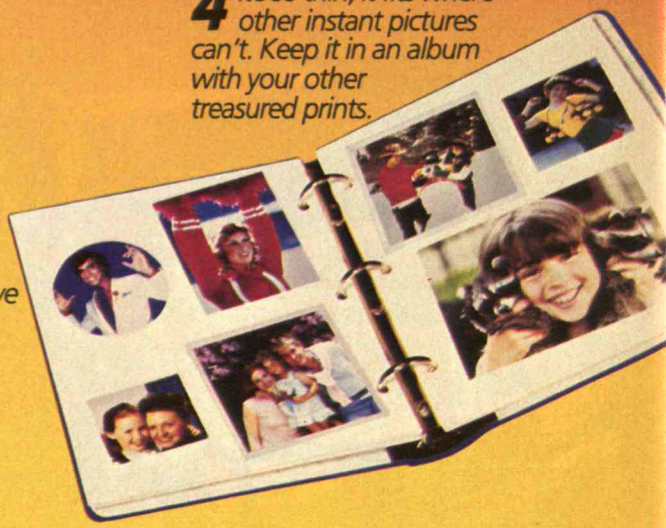
David Copperfield

1 Watch the brilliant color develop before your eyes.

2 Then, any time after an hour, you can lift the picture off the back.

3 Now you have a Trimprint™ without a bulky back. You can even trim it or crop it.

4 It's so thin, it fits where other instant pictures can't. Keep it in an album with your other treasured prints.



This is the most versatile instant film ever, with great color by Kodak. Share it in an instant. Then keep it like a regular print. It's the instant you and your photo album have been waiting for. New Kodamatic™ Trimprint Instant Color Film.
Only for Kodamatic cameras. And only Kodak could pull it off.

Kodak

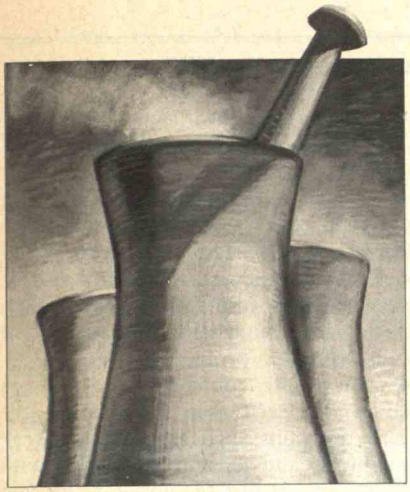
Sarajevo '84
Official Film
XIV Olympic
Winter Games

**IT'S AN INSTANT PRINT.
IT'S A REGULAR PRINT.
IT'S A TRIMPRINT.™**

FEB/MAR 1984 VOL. 87 NO. 2

EDITED AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TechnologyReview



33

60

70

Technology Review

PUBLISHER
William J. Hecht

EDITOR-IN-CHIEF
John I. Mattill

MANAGING EDITOR
Peter Gwynne

DESIGN DIRECTOR
Nancy L. Cahners

DESIGN/
PRODUCTION MANAGER
Kathleen B. Sayre

SENIOR EDITORS
Alison Bass
Tom Burroughs
Jonathan Schlefer

ASSOCIATE EDITORS
Sandra Hackman
Sandra Knight

PRODUCTION/EDITORIAL
ASSISTANTS
Valerie Kiviat
Elizabeth Motzkin

BUSINESS MANAGER
Peter D. Gellatly

CIRCULATION DIRECTOR
Julie Zuckman

SUBSCRIPTION SERVICE MANAGER
Dorothy R. Finnerty

ASSISTANT TO THE EDITORS/
PERMISSIONS
Julie Van Buren

CIRCULATION/MARKETING
ASSISTANT
Deborah Gallagher

Technology Review (ISSN 0040-1692), Reg. U.S. Patent Office, is published eight times each year (January, February/March, April, May/June, July, August/September, October and November/December) at the Massachusetts Institute of Technology. Two special editions are provided for graduate (pp. A1-A32) and undergraduate (pp. A1-A32 and B1-B16) alumni of M.I.T. Entire contents © 1984 by the Alumni Association of M.I.T. Printed by Lane Press, Burlington, Vt. Second-class postage paid at Boston, Mass. and additional mailing offices. Postmaster: send Form #3579 to M.I.T., Room 10-140, Cambridge, Mass. 02139.

Editorial, circulation, and advertising offices: *Technology Review*, Room 10-140, Mass. Institute of Technology, Cambridge, Mass. 02139 (617) 253-8250.

Advertising representatives:
The Leadership Network: 254 Fifth Ave., New York, N.Y. 10001 (212) 684-5500; Benson Co., Park Ridge, Ill.; Joe DeLone & Associates, Riverside, Conn., and Lincoln, Mass.; McKeldin Co., Atlanta, Ga.; Tannerco, Mill Valley, Calif.; and Wm. P. Colley West, Ltd., Hollywood, Calif.

Littel-Murray-Barnhill, 1328 Broadway, New York, N.Y. 10001 (212) 736-1119.

Subscription inquiries and change of address: Room 10-140, M.I.T., Cambridge, Mass. 02139 (617) 253-8292.

Prices:
Single current copies $4 U.S., $5 Canada, $7 foreign. Subscriptions, one year: $24 U.S., $34 Canada, $44 foreign. Back issues available. All prices U.S. funds.

Technology Review is a member of

LETTERS

Training High-Skilled Citizens

In "The Low-Skill Future of High Tech" (*August/September, page 18*), Henry M. Levin and Russell W. Rumberger oppose an "excessive emphasis" on science and math studies, favoring instead a strong general education. When 35 states require only one year of mathematics for a high-school diploma, 36 states require only one year of science, and more than two-thirds of U.S. high schools do not offer physics taught by qualified teachers, we seem to be a very long way from excessive emphasis on science and math. It is also not surprising that Japan graduates twice as many engineers as the United States with only half the population.

The question we should address is to what extent low-skill jobs are dependent on U.S. technological innovation and competitiveness in world markets. We must provide technology-oriented education that is strong in quality and quantity. Without engineers and skilled workers, U.S. businesses cannot move ahead in the increasingly competitive world market. If that happens, the low-skill jobs the authors speak of may not even be available in the numbers they suggest.
S. Thomas Moser
Minneapolis, Minn.

The authors respond:
We share Mr. Moser's concern that the U.S. educational system trains adequate numbers of engineers and skilled workers for our future technological economy. But that does not mean all students will require high-level technical training, especially when the majority are likely to be employed in jobs that will make no use of such training. We endorse the improvement of American education because that will help workers and citizens understand the effects of technology and enable them to determine its influence on their lives.

Attention Librarians

Through a typographical error, the November/December 1983 issue of the *Review* was designated as number 6 in volume 86. It was, of course, number 8—the last issue of the volume. We regret the error—and the confusion it may cause those responsible for filing and indexing.

Don't Blame the VDT

I was surprised that James L. Jones' "Video Radiation: Fears Out of Focus" (*October, page 80*) did not mention a National Research Council report on vision and video display terminals (VDTs) released last July. The study supported Jones' conclusion that x-ray and microwave emissions from VDTs are lower than natural background radiation and are not a cause of vision problems.

However, the council committee was able to cite clear reasons for many of the health problems such as headaches, eye discomfort, and tension associated with VDT use. Inappropriate lighting producing glare on VDT screens; inferior display equipment with wavering images; monotonous, high-stress jobs; and other poor working conditions are largely to blame. The report urged greater attention to workplace and job design to help alleviate the problems of VDT workers.
Barbara Jorgenson
Washington, D.C.

Ms. Jorgenson is director of the Office of Public Affairs, National Research Council.

Keiretsu: Competition or Cooperation?

Charles H. Ferguson's analysis of competition between American and Japanese manufacturers in developing future generations of microelectronics ("*The Microelectronics Industry in Distress,*" *August/September, page 24*) is inadequate. While he makes some excellent points about organizational problems in the U.S. microelectronics industry, Ferguson owes the reader a deeper analysis of the Japanese half of the competitive equation. Technological and strategic infallibility are not among the advantages accruing to firms that belong to the *keiretsu*.
Thomas Lifson and Michael Reich
Cambridge, Mass.

A *keiretsu* (not *kieratsu*) is a group of firms that engage in mutual stockholding and usually belong to a President's Club. The latter may facilitate cooperative activities or supply relationships but does not enable "optimal decision making."

Although firms often depend upon financial institutions in the *keiretsu* for their single largest loans, only a portion of

their total loan capital comes from within the *keiretsu*. For example, in March 1980 Toshiba obtained only 16.2 percent, and Sharp 13.2 percent, of borrowed capital from within their *keiretsu*. Clearly, firms do not have access to unlimited supplies of capital merely by belonging to a *keiretsu*.

Thus, the author's recommendation for similar cooperative activity in the United States is misplaced. The most important lesson to be learned from the Japanese microelectronics industry concerns the intense competitiveness of the firms, both among themselves and with foreign firms.

Robert Evans, Jr.
Waltham, Mass

Mr. Evans, Atran Professor of Labor Economics at Brandeis, was visiting professor at Keio University in Japan.

The difficulties confronting the U.S. semiconductor industry can be explained by a single difference between the United States and Japan. The U.S. government, through antitrust laws, forces manufacturers to compete against one another. The Japanese government, because of the country's lack of natural resources, encourages manufacturers to cooperate to better compete with the rest of the world.

William M. Brobeck
Berkeley, Calif.

The author responds:

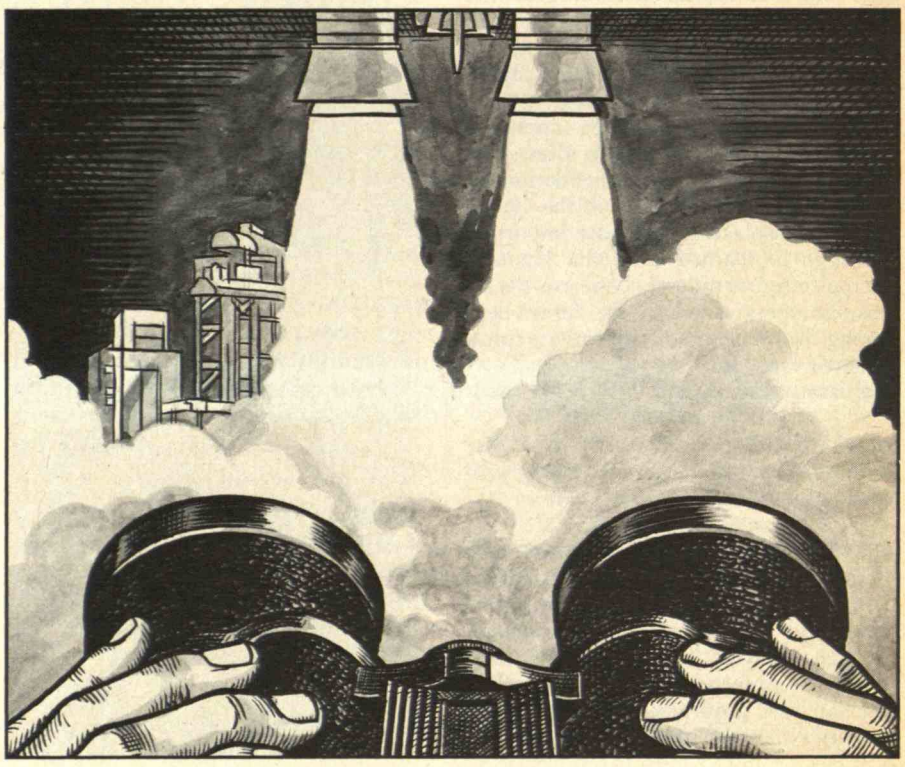
Continuing progress in microelectronics technology is producing a global economic transformation comparable in importance to the rise of industrial mass-production. Nations, companies, and social groups must understand and plan for this transformation if they wish to survive it. Japan is doing so while the United States is not. Thus, the economy and welfare of the United States are already suffering. In the last five years, the U.S. balance of trade in semiconductors has shifted from roughly a $100 million surplus to a $300 million deficit. U.S. unemployment has risen concurrently, partly because of increasing computerization of manufacturing and a failure to retrain displaced blue-collar workers. All the evidence indicates that this is only the beginning.

America's failure to cope with the microelectronics revolution has little to do with antitrust policy. Nor, unfortunately, is "panic" an unreasonable response to the current situation. The U.S. government re-

(Continued on page 30)

ROBERT C. COWEN

A New Spring for Space?



AFTER a decade of lean budgets, with shuttle development claiming much of its resources, the U.S. civilian space program seems ripe for a renaissance. Administration representatives such as science advisor George A. Keyworth II are urging space planners to think big. Planners at the National Aeronautics and Space Administration (NASA) are responding.

NASA Administrator James M. Beggs wants to capitalize on what he has learned during the first quarter-century of the space age. He says that NASA could do some things in the next 10 to 20 years that would be very important for the country. These include more extensive commercialization of space operations, a revitalized planetary and space-science effort, and a new era for manned flight in conjunction with a permanent space station.

The extent to which such dreams actually materialize will depend, of course, on the willingness of the present and future administrations and Congress to underwrite them. But there is a widely held perception within the U.S. space community that the tide of public policy has begun to run in favor of a more vigorous program.

The European space community also senses this. Officials of the 11-nation European Space Agency (ESA) say, in particular, that they consider it important to join in developing the next phase of manned space flight. They see a new era opening for NASA-ESA cooperation.

Three years ago, that cooperation reached a nadir when the United States canceled its half of the joint solar-polar project, which would have sent probes over the north and south poles of the sun. Beggs now calls the decision, made by the previous NASA leadership, "a very bad mistake." He hails the recent European-sponsored Spacelab mission aboard the shuttle as the beginning of a fruitful new partnership.

So does Michael Bignier, director of space transportation for ESA. During the Spacelab mission, he told my colleague Peter Spotts at the *Christian Science Monitor* that the solar-polar wound has healed. Now, he said, "It is clearly the European wish that, if NASA undertakes a space-station project, then we would like to make it a joint venture." NASA planners say a station could be in orbit by the early 1990s. The agency is asking President Reagan to include $200 million "seed money" for the project in its fiscal 1985 budget.

Robert F. Freitag, deputy director of NASA's Space Station Task Force, sees this as a natural evolution of the space agency's overall program. He explains that, in his view, there have been only three major decisions—or turning points—in the U.S. space effort. The first came in 1955 when President Eisenhower decided to develop the Vanguard satellite, which thrust the United States into space. Then, in 1961, President Kennedy's decision to put people on the moon was a move to begin using space, says Freitag. That's when communications, weather, and military satellite programs got underway, as did stronger space-science and planetary projects.

President Nixon made the third major move in 1969, when he decided there had to be a cheaper way to gain access to space than by using costly throwaway rockets. So, when NASA began talking about a space station, Nixon decided to develop the shuttle first, and told NASA to come back with the space-station project later. And that, Freitag says, is what the agency is doing: asking the present administration to make the next major decision by pursuing a permanent presence in space.

Thus, by adding this ambition to their hopes for commercialization and space science, NASA's planners sketch a bright future for the U.S. space program. But some crucial details are in soft focus.

NASA and the Private Sector

One problem is that commercialization is a slippery concept. NASA is not talking about expanding the communications satellite business—that's yesterday's commercialization. Nor is the agency talking about having private contractors launch satellites or manage the shuttle. That would be "privatization," explains Isaac T. Gillman, NASA associate administrator

ROBERT C. COWEN is science editor of the *Christian Science Monitor* and former president of the National Association of Science Writers.

ILLUSTRATION: ROB SAUNDERS

for plans and policy. Commercialization, he says, means the growth of new space-based industries, not private control of activities now performed by the federal government.

However, it is unclear just what those new industries might be. Materials processing is the one usually cited, yet only the electrophoresis process now being developed on the shuttle by McDonnell-Douglas and Johnson and Johnson has any prospect of early application. Electrophoresis is the use of electric forces to separate constituents of a mixture, in this case to obtain high-value pharmaceutical products. On Earth, gravity induces convection currents and turbulence during such a process, making it difficult to refine the product. In the gravity-free orbital environment, the desired purity can be achieved. McDonnell executives have said they expect commercial production of pharmaceuticals in space as early as 1986.

No such statement can yet be made for other forms of materials processing, such as growing large, pure semiconductor crystals for electronic applications. Indeed, Gillman acknowledges that NASA has a lot of missionary work to do with U.S. industry before other prospects for space commercialization become clear.

NASA is hampered in such an effort by communications problems. The agency has a working relationship with aerospace companies, but critics say it doesn't know how to work effectively with the rest of the private sector. Gillman admits this handicap: "We must change our thinking—change our culture—and adapt to the thinking of the nonaerospace world."

Core Maintenance

NASA's vision of the future of space science is in sharper focus. Its so-called core program for planetary exploration—believed to have a good prospect for funding—outlines specific projects for the rest of this century. These include several planetary probes and missions to asteroids and comets, using low-cost spacecraft.

Yet NASA has a major problem when it comes to other aspects of space science. The university space-science community, which has traditionally done the bulk of this research, has fallen on hard times. Its equipment is obsolete or worn out, and it lacks funds to support graduate students. Many premier research groups are struggling to stay alive. A recent NASA-sponsored study concluded that university efforts will soon be insufficient to support the agency's current program.

NASA chief scientist Frank McDonald cites two causes of this problem. First, university space science grew up under NASA sponsorship, but NASA support for facilities, instrumentation, and graduate fellowships evaporated during the budget cutbacks of the 1970s. The recent study urges that about $34 million be added to the annual space science budget for facilities, data analysis, and fellowships. This amount is so modest that it is likely to be granted.

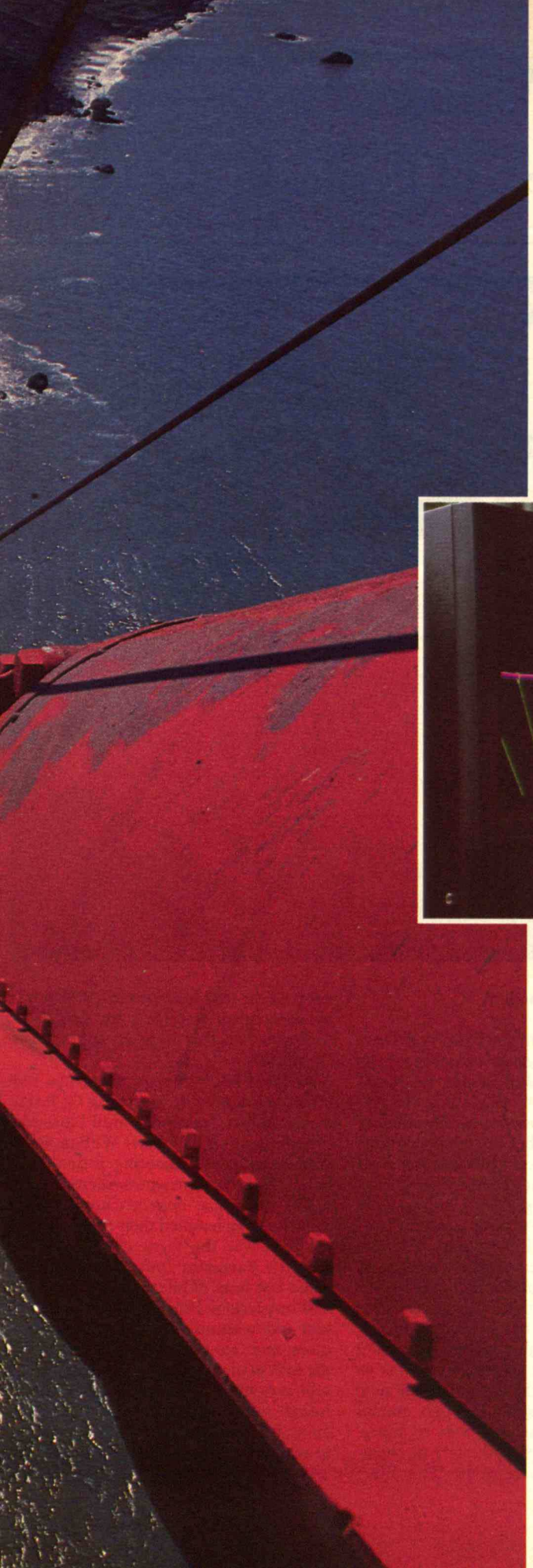
However, the second major problem isn't so easily solved. Spacelab notwithstanding, NASA still hasn't found an adequate substitute for the rocket, satellite, and balloon-carried research packages used by many university groups. NASA is moving toward employing fewer, longer-lived satellites, and sounding rockets and instrument balloons are obsolete. McDonald says that finding a way to include university research within the shuttle framework is a priority for his office.

National Consensus

The remaining uncertainty in NASA's vision is the space-station concept itself. Although many studies exist of facilities that might be built, Beggs says his crystal ball is unclear. Moreover, he is asking for substantial seed money without a national consensus on the goals of manned space flight. And the role of the military—a crucial aspect of any space station—is also undefined. If a space station were to be a joint military-civilian venture, Bignier says it would poison the atmosphere as far as European cooperation is concerned.

Thomas F. Rogers, director of the space-station assessment project of the congressional Office of Technology Assessment, says the country has "far too fuzzy a vision of these goals." He asks, "Without a clearer, more thoughtful vision, how can we expect consensus? And without consensus, how can we rationally make long-term commitments?"

The U.S. space program does indeed seem poised for renewal. But the vision of just what form that renewal should take must be more sharply defined. □



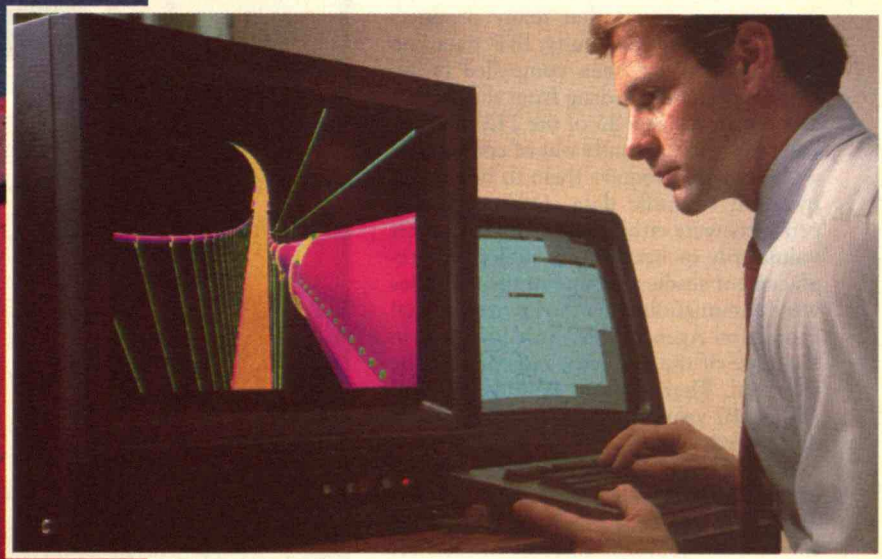
With a complete set of tools, you can build almost anything.

While other companies offer OEMs a few tools to build with, Cadmus provides the complete set.

For example, the Cadmus 9000 combines all the power of a mainframe, the speed of a mini, the price of a micro and the unlimited application flexibility of UNIX™ System V with Berkeley 4.2 enhancements.

All in a distributed environment.

In fact, the system's unique UNISON™ networking software provides the full resources



of the entire network to any computational node through network-wide virtual memory with demand paging.

A 10 Mbit Ethernet™ or 50 Mbit fiber optic LAN serves as the interprocessor bus.

And comprehensive graphics, development and decision support tools facilitate graphics applications in a windowed, multiple process environment.

In addition, we support every Cadmus 9000 with Thunderbolt℠ service that puts an engineer at your door anywhere in the country within 24 hours. Guaranteed.

To get the complete picture on this high powered graphics-oriented distributed system, call Cadmus at 617-453-2899.

The Cadmus 9000. Finally, you've got a complete set of tools.

CADMUS COMPUTER SYSTEMS

The Distributed Mainframe.™

600 Suffolk Street, Lowell, MA 01854
USENET: . . !wivax!cadmus TELEX: 948257

BY ELIOT MARSHALL

The Enduring Problem of Pesticide Misuse

In October of last year, a Chicago jury convicted three former employees of Industrial Bio-Test, Inc. (IBT), of falsifying test data. The long-awaited verdict capped a scandal that has plagued the pesticide- and drug-testing industry for seven years.

Government officials first discovered that IBT researchers were tampering with data on health and safety studies in 1976, triggering a large-scale investigation of hundreds of other IBT studies. Although investigators found that many products were supported by faulty IBT data, no company has yet been compelled to remove a pesticide or drug from the market as a result. At least 35 of the 212 problem cases are still flagrantly out of compliance with laws that require them to be backed by good scientific data. Other pesticide products were either taken off the market voluntarily or became the subject of "replacement studies." Some of these studies were commissioned by the Environmental Protection Agency (EPA) just last July, in the glare of the publicity surrounding the IBT trial. They will not be finished until 1986—10 years after the fraud was first discovered.

Even though all the results are not yet in, top EPA administrators consider the matter closed. At a press conference last July, Edwin Johnson, director of the EPA pesticide office, declared, "The IBT affair has not proved to be the hidden public-health disaster that some had feared."

The IBT affair may indeed be resolved in the EPA's mind, but the issues it raises are not. The motive to cheat is still there. IBT was once the fastest-growing laboratory in the country, conducting over 22,000 toxicity tests between its inception in the 1950s and its demise in 1977. Some credit the company's popularity to the fact that it repeatedly came up with the "right" test results: those that would quickly get a product past the health and safety requirements of agencies such as the EPA.

The laws that would prevent this kind of cheating were not and still are not well enforced. In fact, despite all the publicity the EPA has received in the last year and the personnel shakeups, little was done until late 1983 to ensure that an IBT scandal would not occur again.

ELIOT MARSHALL is a staff writer for the News and Comment section of Science.

ILLUSTRATION: JANE BIANCO

Foot-Dragging at the EPA

When officials from the Food and Drug Administration (FDA) first discovered the IBT fraud, it looked as though the shock waves might start an upheaval in the system of regulating pesticides. Responding to public outrage, the Senate Subcommittee on Health and Scientific Research held a series of well-publicized hearings in 1978 that prodded the agencies involved—the FDA and the EPA—to adopt a Good Laboratory Practices (GLP) program. The new system was supposed to provide for joint FDA-EPA study audits and lab inspections. It mandated that both agencies reject poor data and ban sales of products lacking solid scientific support. According to the new regulations, the FDA was to inspect labs testing the toxic effects of new compounds on humans through animal experimentation; the EPA was to supervise laboratories testing the fate of chemicals in the environment. The FDA adopted the new initiative in 1979, setting more stringent standards for the laboratory test data that must be submitted to its officials.

At the EPA, however, there has been little commitment to enforcing GLP standards. In fact, it was not until November of last year that EPA chief William Ruckelshaus proposed adopting formal regulations for a GLP program there.

The difference between how the two agencies have handled their regulatory obligations was the focus of an article by Stephen Barlas in *Industrial Chemical News* last June. While the FDA conducted 710 inspections between 1976 and 1982, sent out warning letters on 31 problem cases, and rejected 10 studies, Barlas says the EPA made only 140 inspections. Barlas also says the EPA "has never even sent a formal notice to any lab informing it of an audit's findings, much less checked up to see if a lab has mended its ways." The 13 lab audits that turned up problems be-

fore 1982 are still "under review." And no EPA audit has ever caused a pesticide to be removed from the market, according to Barlas.

The pesticide office of the EPA has also been under fire from environmentalists for weakening its definition of carcinogenic compounds, and for permitting a cancer risk in new compounds "10 to 100 times higher" than that allowed by previous administrations. Environmentalists also charge that the EPA has allowed manufacturers to bypass accepted procedures and gain approval for questionable pesticides. "Emergency exemptions" from the normal procedures for clearing pesticides increased from 165 in 1978 to 727 in 1982. "Specific local-need registrations" (approving pesticides for use in restricted areas) also increased from 440 in 1976 to 1656 in 1982 (*see "Menacing Pesticides," May/June 1983, page 81*).

The Latest Controversy

Another more recent controversy centers on the EPA's approval in January 1983 of the fungicide metalaxyl, which may be carcinogenic. According to Charles Benbrook, an aide to Rep. George Brown, Jr. (D-Calif.), and Adrian Gross, the FDA staff scientist who uncovered the IBT fraud, pesticide officials at the EPA did not conduct a truly independent review of the chemical when it first went through the agency's approval system in 1981. Manufacturers were planning to use metalaxyl on apples, broccoli, cabbage, cauliflower, cucumbers, onions, spinach, and tomatoes. Residues would also be present in milk, eggs, meat, potato chips, peanuts, and many other items. Gross believes that because the EPA was in such a hurry to process this application, the reviewer simply copied the data-analysis sections from the industry's findings word for word. As a result, the EPA did not realize until last September, when another staffer analyzed the same data, that use of metalaxyl could pose a cancer risk of 76 new cases per 1,000 people in the general population. The manufacturer, the CIBA-GEIGY Co., disputes this estimate. Meanwhile, the EPA has commissioned a thorough reexamination of the company's findings, a move that seems late in the day considering the fact that metalaxyl is already in widespread use on food crops.

The EPA might be willing to apply a stricter standard for granting pesticide licenses if the Reagan White House or Congress insisted on such a change. But until recently, there has been no indication that this would happen. Since the administration is committed to relaxing regulatory burdens on industry, Congress seems to be the probable arena for action. But there is an obstacle here, too.

Congressional Conflict of Interest

The division of EPA that oversees pesticide regulation—the Office of Pesticide Programs—is itself overseen by the agriculture committees in Congress. Unlike the environmental committees, which have jurisdiction over the clean air and water laws, the agriculture committees are generally more interested in what bothers farmers than in what bothers consumers. And farmers want more pesticides, not more controls on pesticides. Thus, the EPA is under pressure to license chemical compounds quickly and to regard new products as safe until proven otherwise. But environmentalists say that this assumption of the "presumed innocence" of chemicals is thoroughly misguided. They believe the burden should be on the manufacturers to prove beyond a reasonable doubt that pesticides are safe before they are sprayed on our food. Thus, as long as congressional lines of authority remain unchanged, it will be difficult to change the way the EPA pesticide division works.

There have been some hints of reform within the committees. In the past year, Rep. Brown and the staff of the Subcommittee on Agricultural Research have held hearings on the administration's approach to pesticide regulation, reviewing decisions in fine detail and asking for explanations. Brown has also cosponsored a major reform bill that would set deadlines for the EPA in deciding on the safety of new compounds. The bill would also limit the number of "emergency" exemptions permitted by administrative order, and would require the EPA to find a compound safe before allowing its use. Brown recently held hearings on this bill (HR 3818), which is now before both the House and Senate agriculture committees. Unfortunately, few committee members are interested in substantial revision of the pesticide laws. At the EPA's request, the bill has been delayed until Congress reconvenes this year. Even in 1984 the chance that a strong reform bill will pass both the House and Senate is minuscule.

In my view, the only way to bring enduring change would be to shift the jurisdiction for pesticides out of the agriculture committees and into those that regularly deal with public health. Such a change is not being considered and, indeed, would be very difficult. Congress does not often work up enough energy to reassign power among its committees. But until that happens, the public will be stuck with a system of pesticide regulation whose first master is the community that uses and produces pesticides, and whose secondary concern is public health. □

BY ROBERT A. SPANNER

Trade Secrets versus Technological Innovation

THE United States is on the cutting edge of the world's transformation from capital-based to information-based economies. Now, more than ever, new technology rather than capital formation is the driving force behind American economic activity and growth. The rate of technological change is also one of the principal determinants of our ability to compete in world markets. Technological innovation has thus become a matter of public interest and national policy.

In the United States, most technological innovation has historically been generated by the small entrepreneurial firm. And of course, the most fertile sources of entrepreneurs are the ranks of other companies in the same industry. Not many new ventures will succeed—or be funded—without managers experienced in the trade they are proposing to enter. So any significant restraint upon the flow of employees into new ventures could curtail the rate of innovation in this country.

Consider, for example, the founding of Intel. Robert Noyce and Gordon Moore, then executives at Fairchild Semiconductor, Inc., had difficulty interesting top management in large-scale integration, a technology for putting thousands of transistors on a single computer chip. So they founded Intel and developed the RAM high-density memory chip, which started the process toward miniaturized chips and significantly changed the world's technological landscape. Had the mobility of these entrepreneurs been obstructed, a significant technological development would have been delayed.

But today entrepreneurs have to run a legal gauntlet that was not of such concern to their predecessors. The use of nondisclosure agreements between employee and employer, designed to prevent the distribution of information, is becoming more prevalent. Furthermore, such contracts are being enforced more aggressively. These agreements, together with the threat of litigation they represent, could seriously hobble the rate of technological innovation in the United States.

The Trade-Secret Tightrope

Despite sensational cases such as the recent IBM-Hitachi litigation, most disputes over trade secrets are prosaic affairs between corporations and their former employees. These cases, which often arise when an entrepreneur uses information acquired during former employment, can occur under one of three circumstances. First, the departing employee passively receives and uses proprietary information that she or he had no hand in developing. Second, both employer and employee contribute substantially in developing a technological innovation. And third, the proprietary information is mainly the product of the employee's own initiative, creativity, and diligence, with the employer as the passive recipient.

No one would seriously contend that employees have the right to walk off and use trade secrets conferred upon them in confidence, no matter how much that might promote entrepreneurial activity. Without legal protection against such conduct, many companies might well regard research and development as futile. Moreover, this kind of conduct offends basic notions of morality and fair play. Even in the second situation, where employer and employee have each contributed substantially to the development of an innovative device or process, a good argument can be made against an employee's use of proprietary information. A company, by virtue of having expended perhaps millions of dollars on an R&D project, ought to

ILLUSTRATION: YEVGENY YELCHIN

have a claim to the information superior to that of any individual contributor.

But consider the third case, where employees, by dint of their own initiative, and perhaps even over the opposition of their employers, design some significant technological advance. Should those employees be foreclosed from using the development, or the information inherent in it, which they alone have brought into being? Suppose further that the employer declines to market the employee's discovery, either because the company believes it will not be technologically feasible or economically viable, or because discovery threatens the corporation's investment in its existing product line. Should employees be prevented from using their own handiwork, even if that would result in the suppression of the technology altogether?

Consider another thorny issue in trade-secret law. Many companies require their employees to assign to the firm all rights to ideas, inventions, and discoveries they conceive of during their employment. But what if employees have ideas for a product or process to which their corporate employers refuse to dedicate resources? Should these agreements foreclose those employees from all opportunity to pursue their ideas on their own?

Courts throughout the country have been struggling with questions such as these for the last two decades and longer. Although no consensus has emerged, the potential for trade-secret rulings to adversely affect entrepreneurial activity is clearly substantial. In one example, a geologist employed by Chevron Oil Co. had developed a theory that indicated the existence of oil in a particular geological formation. He repeatedly urged Chevron to drill in accordance with his theory, but his superiors remained unconvinced. Frustrated with Chevron's inaction, the geologist resigned, took out oil leases in the subject area, and negotiated a drilling contract. But Chevron brought suit and the court shut him down, ruling that his theory was Chevron's trade secret.

In a similar case, when two employees of a manufacturer of tennis-ball machines conceived of a design for a smaller, lighter, and cheaper machine, management showed no immediate enthusiasm for the idea. The employees then set up their own company to manufacture the machine. Even though the company didn't plan to develop its own tennis-ball machine along the lines suggested, the company sued its former employees for misappropriation of trade secrets. Once again, the court ruled in the company's favor, requiring the employees to assign all their rights to the machine to their former employer.

The Exception That Swallows the Rule

Some legal decisions do hold that employers have the exclusive right to all ideas, theories, and information relating to discoveries or developments that employees create essentially on their own. But more recent cases indicate a trend toward conferring on both employer and employee an equal right to use information primarily developed by the employee. However, most companies require employees to sign away that right in a nondisclosure and confidentiality agreement.

In the early 1970s, for instance, two employees of Structural Dynamics Research Corp., an Ohio engineering-sciences firm, developed a computer program for the structural analysis of buildings that was superior to anything then on the market. These employees formed a new company and developed a similar program. The court ruled unequivocally that the employees had the right to use the program for their own purposes: "If the subject matter of the trade secret is brought into being because of the initiative of the employee in its creation, innovation or development, even though the relationship is one of confidence, no duty [of nondisclosure] arises since the employee may then have an interest in the subject matter at least equal to that of his employer, or in any event, such knowledge is a part of the employee's skill and experience."

However, the judge carved out an exception that will, in most instances, swallow the rule. The employees had signed detailed nondisclosure agreements. Therefore, the court held that they could not use the fruits of their own creativity, because "the agreements not to disclose confidential information . . . do not exclude information, technology or knowledge which the employee himself discovers, develops or contributes."

In addition to a nondisclosure provision, employment agreements also usually contain an invention-assignment provision, which is even more troublesome from the perspective of new-venture formation. These agreements require employees to assign their rights to all

Continued on page 58

Macroprojects, Worker Control, and Humanistic Cosmology

Light at the End of the Macrotunnel

Macro: A Clear Vision of How Science and Technology Will Shape Our Future by Frank P. Davidson with John Stuart Cox, photo research by Vincent Virga William Morrow and Co., 450 pp.

Reviewed by Henry Petroski

To hear computer scientists tell it, *micro* is the prefix that heralds our technological future. We have the microelectronics industry producing microcomputers and microprocessors to give us a brain on every desk and a robot in every kitchen. Even when they speak of "very large scale integrated" circuits, on the rare occasions when they do translate the unpronounceable VLSI, the engineers and scientists of the post-Industrial Revolution have in mind microminiaturization.

The popular media seem to have become charged with this enthusiasm, and they have promoted the microrevolution as if it were the nation's only economic hope. The more traditional concerns of engineers—such as the mechanical machinery that provides heat in winter and cold in summer, the chemical products that clothe and adorn us, and the civil structures that give us space and shelter—hold none of the glamour of microelectronics. The mundane infrastructure is news only because its accelerating deterioration threatens to impede the arrival and enjoyment of the total electronic revolution. Still, there are signs that the microelectronics industry may be tripping over itself. The bankruptcy of Osborne Computer Corp. and the decision of Texas Instruments to stop making home computers can be blamed on little but overcrowding on the road to Eldorado.

Thus, Frank Davidson's book, defiantly titled *Macro* and bucking the tide of microthought, comes as a welcome change. Although his is not a book against the microelectronics industry, Davidson does point out that the maximum number of new jobs expected from high-tech industries, including bioengineering and robotics, over the next decade is less than a million, and most of those will be in traditional occupations rather than technical ones. Enrollments in electrical engineering and computer science departments, now

rapidly expanding, may soon drop as precipitously as a lead balloon. In the meantime, however, these disciplines are siphoning off some of the most able and ambitious students from less glamorous fields such as civil engineering. This situation could in fact hamper the U.S. economic recovery.

According to Davidson, it is time to "go macro" to rebuild the U.S. economy. By macro, Davidson means civil-engineering projects as large as any this planet has heretofore seen. He dreams of a trans-Atlantic tunnel, a U.S. summer capital city in the West, and a continental water-supply system as easily as microengineers dream of disposable electronic gadgets. What Davidson wants to concentrate on is the infrastructure of the future, the building of which will not only provide jobs but also repay the necessary capital investment many times over.

Networking for Success

Implementing such grand plans will take a new breed of engineer-manager, Davidson recognizes. The present separation of engineering and management schools in the United States is not conducive to producing the type of individuals he believes will be required to bring to fruition macroengineering projects. Such endeavors require diverse talents, of which engineering is but one. Indeed, the technical obstacles can be trivial compared with the economic, political, and social hurdles. Apparently, even M.I.T., where Davidson is chairman of the Systems Dynamics Steering Committee of the Alfred P. Sloan School of Management, does not have enough interaction among its engineering and management faculty to produce the kind of talent he thinks essential. What this country needs, according to Davidson, is a system of higher education akin to that epitomized by France's Ecole Polytechnique, whose graduates have an entree into the political and industrial network of power unequaled anywhere else.

Indeed, if Davidson's book has one overall message, it is that engineering projects require more than engineering for their success, especially when carried out at the macroscale. Lawyers (whom Davidson terms "institutional engineers"), politicians, and even public-relations people must all come together in the right combination to make a macroengineering project work. According to Davidson, truth "is inherently interdisciplinary," and presumably so is success. A team of engineers working independently of politicians and business leaders is not likely to achieve success in a macroproject. It takes a microcosm of the power structure to bring a macroidea to fruition.

In anecdote after anecdote set in the restaurants, offices, and conference rooms off the corridors of power, Davidson convincingly shows that it is not what you know but who you know that counts when selling macroideas. At times his book reads like William F. Buckley, Jr.'s, recent book *Overdrive*, in which that conservative role model flits from one significant engagement to another, with some important leisure activities in between.

However, the reader can easily get an early impression from Davidson's book that he has tunnel vision—literally and, to a certain extent, figuratively. He clearly gets most excited when describing "planetran," a supersonic subway that could cut travel time between the East and West Coasts to 20 minutes; a trans-Atlantic tunnel that would open a commuter route between the United States and Europe; a tunnel under the English Channel; and, ultimately, a tunnel system around the world. Indeed, tunnels are the mode of

ILLUSTRATIONS: JIM CARSON

travel of the future, to hear Davidson tell it.

But the details of their execution are muddy. At times Davidson speaks of using nuclear explosions to advance tunnels, and at others he speaks of constructing cross-continental tunnels with tolerances that would certainly test the state of the art. He doesn't address the problem of how such tunnels would survive earthquakes. And readers might wonder how Davidson would deal with bottlenecks such as that between New York and New Jersey today, where commuter traffic, which has come to rely on the Holland and Lincoln tunnels, will be tied up for the rest of the decade while the aging Hudson River tubes are being fixed. But then, for all his celebration of large-scale engineering projects, Davidson is not an engineer but a lawyer by training who has come to be a broker of macroideas.

Venture Time

What Davidson does effectively is point out the difficulty of raising capital and maintaining interest in even relatively small large-scale projects such as a tunnel under the English Channel—an idea almost two centuries old. Engineers drew up their preliminary plans long ago, and construction actually began about a hundred years ago. Test tunnels reached about a mile from shafts sunk in England and France, and everyone important seemed to be squarely behind the project, until the British War Office objected because the tunnel would provide an invasion route to the insular kingdom.

Indeed, the time from conception to completion of most, if not all, macroprojects can stretch into decades and even centuries. Yet the political time scale—an arena in which power usually changes every few years—is not long enough to provide stable funding support for macroprojects. Thus, Davidson calls for more private-sector backing for such projects. He recognizes that the most difficult phase of a macroengineering project may be the raising of venture capital and venture *time*. The grandest engineering scheme will get nowhere, he points out, if the engineer does not have the time to court the people with the money to finance it. And time, according to Davidson, is not obtained by submitting long, detailed feasibility studies but by relying on one's friends of long standing to support one's plans.

One curious thing about Davidson's book is that it, too, seems to have been made by committee. John Stuart Cox, identified as a "veteran and professional wordsmith," is listed as coauthor, and in type to test anyone's vision, Vincent Virga is credited with doing the photo research. How Cox could prepare a first draft and Davidson type the pages of the manuscript himself (as mentioned in the acknowledgements) may remain one of the mysteries of macropublishing.

The illustrations in *Macro* also seem to be somewhat at cross-purposes with the text. For example, a photograph of a Comet—Britain's post-World War II jet airliner—on its maiden flight seems ironic in light of the mid-air failures of several Comets within a year of being introduced into commercial service. The Comet is one of the classic failures of a macroproject, and the photograph merely emphasizes the fact that such ideas do not always fly.

But whether or not Davidson ever sees the light at the end of any of his macrotunnels, he still makes an important contribution to technological literacy. Both engineers and lay readers can learn much about engineering projects from his book. And Davidson drives home the idea that technology, whether macro or micro, always involves more than engineering. □

Henry Petroski is associate professor and director of graduate studies in civil and environmental engineering at Duke University.

Giving Workers Control

Industrial Renaissance: Producing a Competitive Future for America
by William Abernathy, Kim Clark, and Alan M. Kantrow, Basic Books, $19

Reviewed by Herbert Gintis

America's fall from grace in the international economy, dating from the last years of the Vietnam War, has been sure and swift. At first the U.S. public was treated to facile excuses. The fault for America's declining trade position was laid variously upon Arab sheiks, fickle consumer tastes, the unfair trade practices of foreign governments, and the low wages of our trading partners throughout the world.

The time for excuses appears to have ended. The American public now is far more open to fresh and innovative interpretations of economic ills than at any time since the Great Depression. The Reagan presidential victory was in this respect a true watershed. Conservatives may have rejoiced at the surfacing of the silent majority, but Ronald Reagan is the first president to have run and been elected on a truly radical, indeed idiosyncratic, economic platform.

Yet the performance of the U.S. economy during the Reagan administration has been disappointing. Even the appearance in late-1982 of the long-awaited economic upswing, still in progress, gives little basis for optimism. Productivity and per capita income have grown at about half the rate of other post-1950 business recoveries, while unemployment rates have moved only marginally downward. Moreover, real investment, which declined by 5.5 percent from 1981 to 1982, was expected to fall another 3.1 percent in 1983, according to the Department of Commerce. Thus, the upswing is likely to be both weak and short-lived.

This failure of the current economic program has opened the way for equally radical alternatives. Indeed, economic cure-alls have replaced fad diets at the top of the best-seller lists. William Abernathy, Kim Clark, and Alan Kantrow, authors of

Industrial Renaissance, fit clearly among this new breed of innovators. They argue that to extricate itself from the current economic decline, the United States must recast its labor-management relations along the lines pioneered by Japanese industry over the past two decades.

Self-Centered vs. Subservient

The authors dismiss several reasons often given for the strikingly superior performance of the Japanese automobile industry, on which they focus their case. To the suggestion that American firms miscalculated the demand for small cars, the authors respond that U.S. producers required the high profit margins from large vehicles to cover numerous production inefficiencies. To the suggestion that U.S. producers face crippling labor costs, the authors note that the lower transportation costs of domestic firms provide a nearly equal counterbalance. To the notion that American plants are outdated compared with the computerized operations of the Japanese, they simply say "not so!" For one thing, the replacement value of plant capital per automobile produced in the United States is $4,300 to $5,000, compared with $2,100 to $2,300 for the Japanese. For another, the authors' on-site investigations convinced them that computerized assembly is limited to a relatively small portion of Japanese auto manufacturing.

The difference between the Japanese and U.S. auto industries, the authors maintain, lies in the markedly superior worker productivity of the Japanese. A vehicle that requires about 80 person-hours to produce at Ford or General Motors demands only about 50 person-hours at Toyo Kogyo (maker of Mazdas) or Nissan. The quality of the final product, measured by the number of defects per vehicle, is also significantly superior in Japanese factories. The Japanese reputation for high quality and low price, they conclude, both stem from the same source: the quality of Japanese labor.

Of course, Abernathy, Clark, and Kantrow could have taken refuge in cultural stereotypes, contrasting the humble, subservient, and selfless Japanese with their belligerent, fiercely self-centered U.S. counterparts. Indeed, many observers have complained about a decline in the American work ethic—including not a few U.S. managers. But these authors maintain that the key lies with management: in the more efficient patterns of Japanese labor-management relations.

During the bitter labor struggles of the 1930s and 1940s, U.S. workers relinquished all demands for participation and control in the workplace in return for the power to demand high wages and guaranteed working conditions. Thus, management has maintained virtually complete hierarchical control of production. U.S. workers have been little more than appendages to machines, forced to assert their claims to dignity and autonomy through the absurdly counterproductive strategy of thwarting management's projects at every possible turn. Raising productivity in U.S. plants has therefore come down to bludgeoning the workers, observe the authors. "As one foreman noted, 'Let's face it. The only way to get things done is to get down on the floor and knock a few heads. Knocking heads might not win management any friends on the shop floor, but who needed friends.' "

The stress in the Japanese system—by now well known—is upon worker initiative and participation. Labor is rewarded by a judicious combination of wages and the pride of craft associated with a job well done. The Japanese worker, in short, is not subservient but empowered.

One scenario contrasting the two countries' systems drives home the point. "In an American plant [when an assembly line shuts down], the foreman and machine operators would try to puzzle out what had gone wrong, would call in the appropriate craftsmen to fix it, and would dicker at length about which skilled trades had jurisdiction over which part of the problem. . . . At Toyo Kogyo, by contrast, the operator immediately began to work on his own machine with the help of the foreman while nearby workers pitched in to clean the line of clogged work-in-progress. In 1981, teamwork of this sort kept downtime for Toyo Kogyo's transfer lines to but 3.9 percent—and for car-body welding lines to but 1.4 percent—of operational time. The comparable numbers for American plants are much higher."

Worker Self-Management

My own research, and that of many of my colleagues, shows that such productivity decline—not unemployment, inflation, or fiscal irresponsibility—lies at the heart of the overall economic crisis in America. This decline is partly due to factors such as inadequate nonmilitary R&D and investment, energy price increases, environmental controls, and excessive government regulation. However, my analysis shows that 81 percent of the productivity decline from 1966 to 1973 stems from a decrease in intensity of workers on the job and an increase in strike activity. (The remainder is due to a decrease in innovation and in the use of manufacturing capacity.) And at least 41 percent of the productivity decline of the most recent decade was likewise due to changes in work intensity and labor resistance, despite the worst economic downturn since the depression. As energy prices stabilize further and productivity remains low, more analysts will undoubtedly use labor factors to explain lagging U.S. economic performance.

At the same time, increases in worker initiative and responsibility, ranging from mild "quality-of-work-life" programs to full-blown worker self-management, have raised productivity in many companies. For example, the many worker-owned and worker-controlled firms in the U.S. plywood industry have shown much higher than average productivity since the 1950s. Indeed, when challenged by the Internal Revenue Service for paying workers high wages and deducting these costs, the companies proved that higher wages were justified by their 25 to 60 percent above-average productivity.

Clearly, though, the future of worker participation in America will prove bitterly contentious. Our institutions are not set up for such programs. Management jealously guards its prerogatives, and unions are not inclined to cooperate in devising forms of labor-management relations that reduce their pivotal role.

Yet initiatives in this direction are inevitable. As surveys by pollsters Daniel Yankelovich and John Immerwahr show, workers are increasingly interested in a participatory economy. Perhaps, prodded by the faltering of the American Dream, our society will attempt to extend to the workplace, and perhaps even to economic relationships in general, the concepts of democracy and participation of which we are so proud. This would be an "industrial renaissance" worthy of the name. □

Herbert Gintis is professor of economics at the University of Massachusetts at Amherst.

Toward a Humanistic Cosmology

The Return to Cosmology: Postmodern Science and the Theology of Nature
by Stephen Toulmin
University of California Press, $19.95

Reviewed by David Layzer

Science and religion have different but compatible aims. Science seeks to deepen our understanding of the world; religion seeks to develop a feeling of personal connection and harmony with it. For many creative scientists, including Newton and Einstein, scientific thought and religious feeling have gone hand in hand. Yet science has continually come into conflict with religious cosmologies, or theories of the universe and humanity's place in it.

It is not hard to understand why. Religious cosmology is holistic: it sees "a world in a grain of sand." Science is reductive: it takes as its motto "divide and conquer." Religious cosmology is concerned with feeling and will; science constructs the universe from particles and abstract symmetries. Religious cosmologies derive their authority from personal belief; science, from impersonal evidence.

Science has steadily gained ground during the last four centuries while religious cosmology has lost ground. The medieval world picture began to crumble under the impact of the astronomical discoveries of Kepler and Galileo. In the seventeenth century, Newtonian physics demonstrated the universal obedience of matter to mathematical laws. Newton himself still believed that God had caused luminous matter to collect in suns and placed the planets in their orbits. But by the end of the eighteenth century, Laplace's mathematical analysis of the stability of the solar system had removed the need for a divinity to maintain the machinery of the cosmos.

Still, religious cosmology governed the vast realm of biological and, above all, mental phenomena. However, in the nineteenth century, Darwin and his followers built a detailed explanation of the diversity and adaptability of living organisms. And in this century, biochemists discovered the elementary processes involved in metabolism, muscle contraction, vision, and the transmission of genetic information. Before the end of the century, scientists may well succeed in understanding how the

first cells came into being. Only one important aspect of the world still eludes scientific understanding: mind. Some researchers believe that they have come up against a natural boundary in studying mental processes; others—I think the majority—regard it as a frontier.

Blind Men Studying the Elephant

But if science is making religious cosmologies obsolete, can it provide a world view that will be emotionally as well as intellectually satisfying? Stephen Toulmin, professor of social thought and philosophy at the University of Chicago, addresses this question in the essays in *The Return to Cosmology*. Toulmin argues that, contrary to the opinion of most scientists, questions about the universe as a whole lie outside the scope of the natural sciences. Scientific cosmological theories, he says, have the same mythical character as the religious cosmologies they seek to supplant. And far from helping us feel at home in the universe, modern science promotes feelings of isolation and alienation, because the scientist's account of the world is impersonal. Science cuts us off from nature by casting us in the role of passive observers.

Toulmin offers two arguments to support his contention that science cannot make valid statements about the universe as a whole. First, scientists formulate laws for ordinary physical systems, but the universe is not such a system. Therefore, these laws are not cosmological. However, Toulmin fails to realize that physical laws actually apply to processes, not to isolated systems, which do not exist in nature. For example, the second law of thermodynamics says that heat conduction and friction generate entropy—or cause large-scale order to decay. Since this law is not limited to a particular part of the universe or period in its history, it is a cosmological law. Similarly, some processes generate order. For example, DNA creates chemical order by directing the synthesis of proteins, nucleic acids, fats, and carbohydrates in living cells. The complex web of order- and entropy-generating processes is not yet fully understood. But I know of no reason why we should not one day understand it at least as well as we understand, say, the rise and fall of political systems.

Toulmin's second argument against scientific cosmology stresses the reductive nature of scientific research. Science, he says, is an "aggregate of independent disciplines," each of which describes a narrow aspect of the universe through specialized concepts and theories. Natural scientists seeking to understand the universe as a whole are therefore like the blind men who set out to study an elephant.

But Toulmin assumes that the outcome of science must resemble the process. Modern scientific research is indeed highly specialized and becoming more so. Yet as individual disciplines proliferate, their underlying concepts and laws become fewer, deeper, and less specialized. Newton showed that Archimedes' theory of floating bodies, Galileo's theory of falling bodies, and Kepler's laws of planetary motion were all consequences of a few simple mathematical laws. Maxwell's theory of electrodynamics united electricity, magnetism, and optics. Einstein's theories abolished the distinction between energy and mass. Quantum mechanics reduced theoretical chemistry to a branch of physics. Likewise, by laying bare the chemical basis of life, biologists, chemists, and physicists have at last succeeded in uniting the two great branches of natural science. And some of the deepest questions concerning

(Continued on page 30)

The conservation ethic finds one of its highest expressions in remanufacturing—remaking old products to be as good or better than new. Replacement parts for automobiles and trucks are the largest single application of remanufacturing in the U.S.

Remanufacturing

BY ROBERT T. LUND

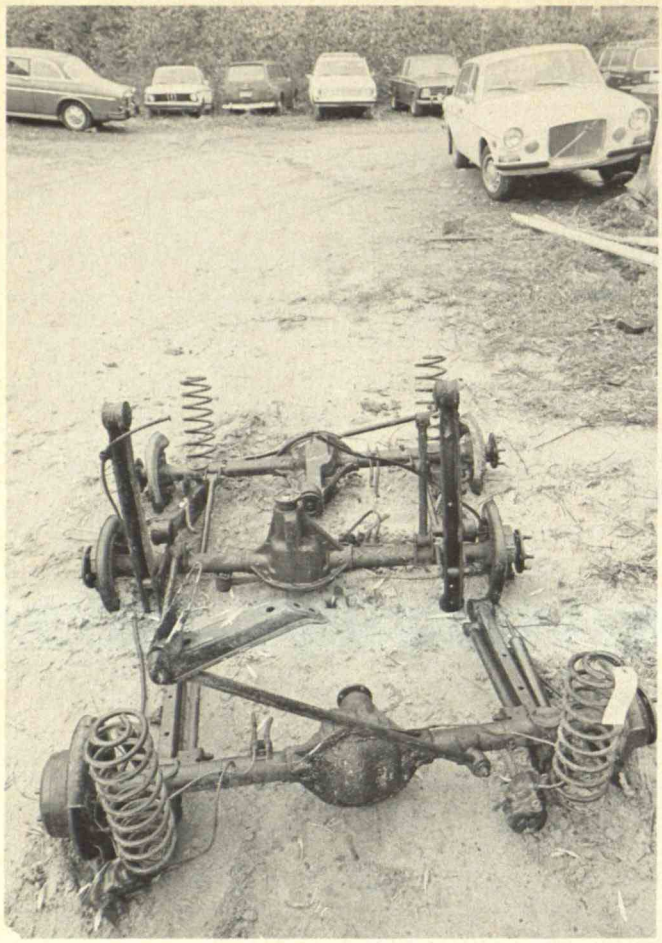
WHEN a durable product such as a machine, appliance, or automobile wears out, most of us simply discard it and buy a new one. But there is an alternative: have the product remanufactured. This approach, used more often behind the scenes in manufacturing than most of us realize, is destined for a greater role as energy and materials become scarcer.

Remanufacturing is an industrial process in which worn-out products are restored to like-new condition. Through a series of industrial processes in a factory environment, a discarded product is completely disassembled. Usable parts are cleaned, refurbished, and put into inventory. Then the new product is reassembled from both old and, where necessary, new parts to produce a unit fully equivalent—and sometimes superior—in performance and expected lifetime to the original new product. In contrast, a repaired or rebuilt product normally retains its identity, and only those parts that have failed or are badly worn are replaced or serviced.

The assembly and testing processes of remanufacturing are usually very similar to those used in making the product originally. Because the remanufactured product is expected to function like a new one, remanufacturers find themselves in competition both with conventional repair facilities and with makers of new products. In fact, most remanufacturing businesses are outgrowths of either independent repair businesses or the service operations of original equipment manufacturers.

Remaking worn-out products to perform as well as new ones saves materials, energy, and money while creating jobs. But our infatuation with newness too often deprives us of these benefits.

PHOTOGRAPHS: CHRIS MAYNARD



Stages in the remanufacture of Volvos at Automotive Import Recycling are shown roughly in sequence in this panel of photographs. Cars are completely disassembled, and engine parts rebuilt as necessary. Meanwhile, bodies are stripped of fixtures and paint, ground and welded to original contours, and repainted and reassembled with new interior materials. Final reassembly yields a like-new vehicle on which AIR gives a 12,000-mile-or-12-month guarantee. The cost: about $6,000.

Remanufacturing usually begins when the service facility recognizes the profit potential and other benefits of such a business.

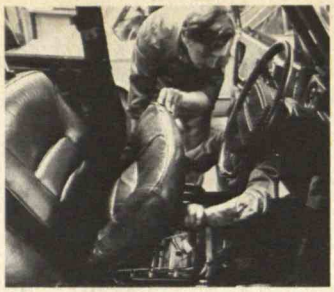
Remanufacturing is profitable and efficient when a large fraction of materials used in a product, and the value added to it when it is made, can be recovered at low cost compared with that of original manufacture. Remanufacturing affords significant conservation of materials and energy; there are significant employment opportunities, especially for low- and moderate-skilled workers; and solid-waste-disposal problems are reduced. Thus, remanufacturing has an important role in the economy—and could have a larger one.

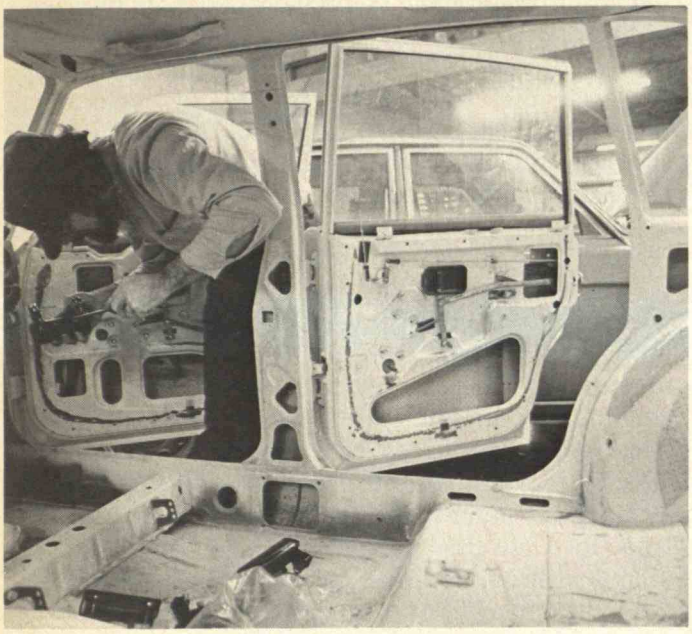
Although it has had low visibility, remanufacturing has been a viable economic activity in many parts of the world for decades. Yet its benefits and the conditions under which they can be maximized are little studied. Indeed, this article is based on the only comprehensive study of remanufacturing of which the author is aware, undertaken in the Center for Policy Alternatives at M.I.T. from 1979-1983.

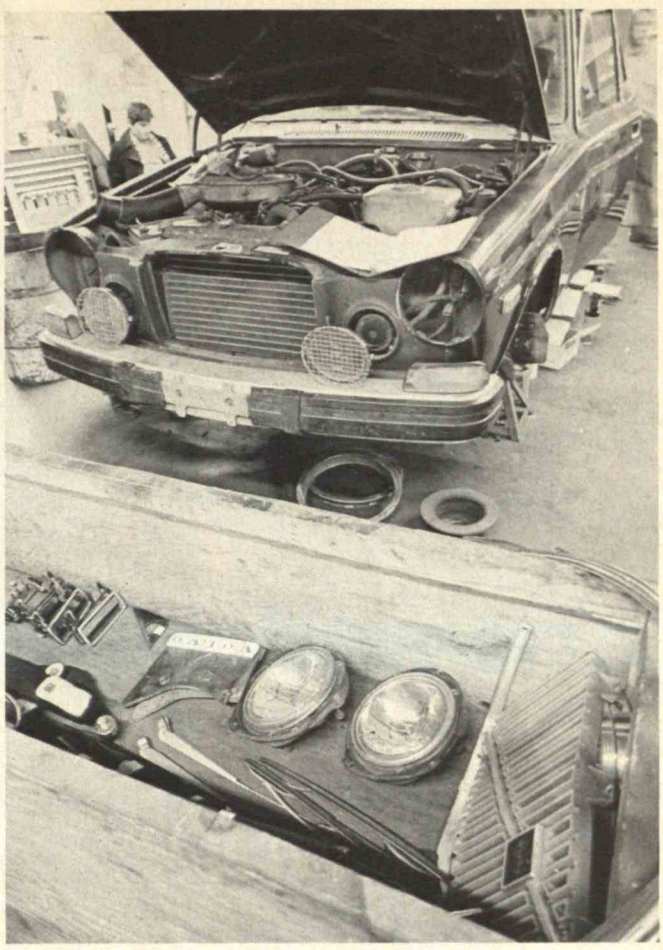
Virtually any manufactured product, device, or mechanical system can be remanufactured. The major requirement is that there be a discarded product, called a core, in which the cost of salvaging the materials and the value added is much less than the market value of the remanufactured item. For example, the difference between the price of a new automobile starter and of a faulty discarded one is large; the starter can be restored to full function for far less than the cost of producing a new one.

The product must also be capable of being disassembled—remanufacturers become adept at taking apart even the most intractable units, including welded joints, swaged fasteners, hermetic seals, corroded unions, and the like. The core's parts must be capable of being economically repaired, refurbished, or replaced, so that the original function and performance level are restored. And there must be a continuing demand for the product—it must be technologically stable. The fact that a remanufactured product may be as much as ten years older than current models cannot be a deterrent, and may even be an advantage to purchasers. For example, even if electromechanical adding machines satisfy all physical and economic criteria for remanufacturing, no one wants them. Inexpensive electronic calculators have taken over the market. On the other hand, there is a lively market for remanufactured parts for equip-

In four years AIR has remanufactured 400 cars while gradually learning how to do the job cheaper and better, and the company is now looking for a site larger than its present shop in Belvidere, N.J.







ment no longer being made but still in common use, such as older cars and trucks.

The range of commercial products being remanufactured in the United States is broad and can be divided into four general categories:

☐ *Automotive.* Replacement parts for automobiles and trucks are the largest application of remanufacturing in the United States today. These products range from simple starter solenoids to complete diesel engines. The routine remanufacture of whole automobiles, in contrast to custom rebuilding, is a promising innovation. (*See page 26.*)

☐ *Industrial equipment.* Remanufacturing is now commonplace for such products as process valves, hydraulic equipment, heavy-duty diesel engines, production metalworking machinery, and oil-drilling equipment. Since these products are frequently custom-made for specific uses, they may also be remanufactured on a custom basis.

☐ *Commercial products.* Office machinery, compressors for commercial refrigerators, vending machines, and communications equipment are often remanufactured. One of the first major manufacturers to exploit remanufacturing extensively was Western Electric, which collects, remakes, and distributes telephone equipment for the Bell System.

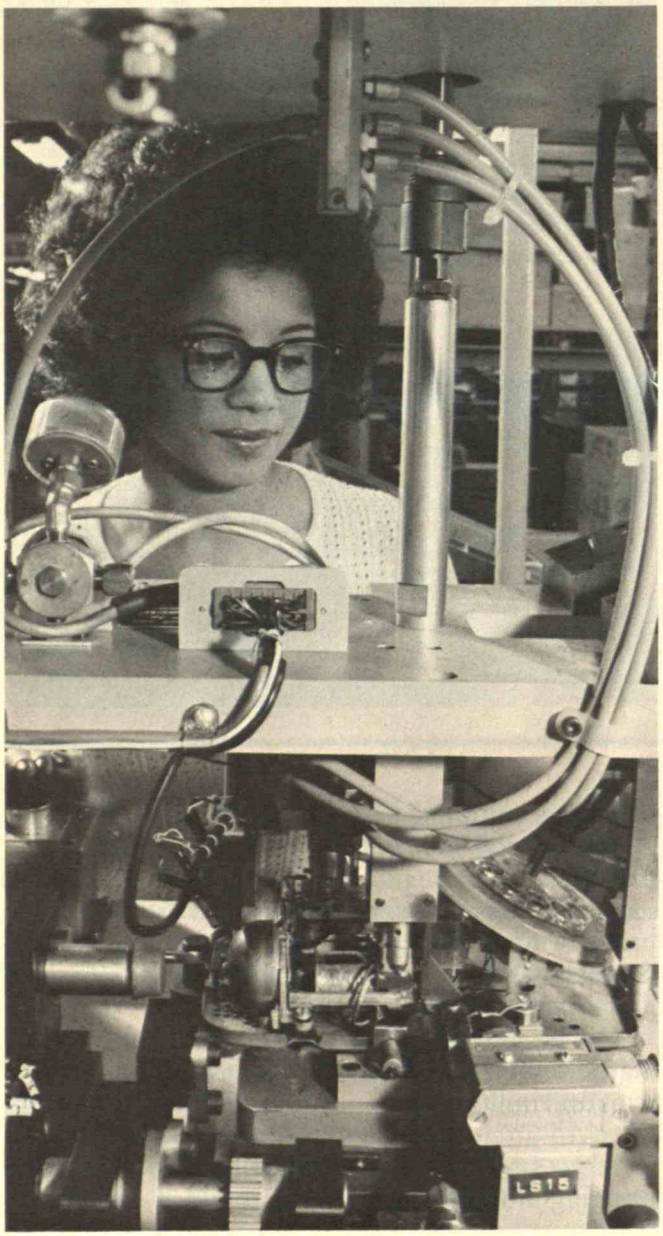
☐ *Residential products.* A few power tools, lawn mowers, and appliances are being remanufactured. However, the diffuse market for used products, long product lifetimes, and high transportation costs, coupled with consumer prejudice against "rebuilts," limits remanufacturing in this sector.

The largest single remanufacturer in the United States is the Department of Defense. Weapons systems and military equipment, ranging from rifles and radar to aircraft carriers, are regularly remanufactured to save the cost of acquiring new ones while bringing modern technology into older equipment.

The Imperative of Quality Control

The remanufacturing cycle begins when a user relinquishes a faulty or worn-out product—through trade-in, sale, abandonment, or contract—to the system that collects and forwards these cores to a remanufacturer. Because many cores are traded in when their owners purchase new items, retail dealers tend to be the initial collection point. Warehouse distributors and salvage yards are also major suppliers of cores. Core supply is a crucial—and often

Manufacturers of original equipment could often be more helpful than they are to remanufacturers, by using more care in designing products and by freely sharing technical data.



Western Electric was one of the first U.S. companies to exploit remanufacturing. Large amounts of telephone equipment in use today by companies and consumers formerly associated with the Bell System are the products of this program, one of the world's largest remanufacturing operations.

limiting—factor in remanufacturing capacity, so each remanufacturer seeks to receive a core for each unit sold. High-value components such as machine housings or crankshafts cannot economically be reproduced, and the number of these items that can be salvaged determines the number of remanufactured units that can be produced. The demand for cores is sometimes keen enough to support independent collectors, called core brokers.

Obtaining a supply of cores of good quality at a reasonable price is especially difficult for a firm establishing a remanufacturing venture in a new field with no tradition for the exchange of old units when new ones are purchased. Original equipment manufacturers could often be more helpful than they are, as some see remanufacturers as competitors. In some situations of this kind, remanufacturers have found it expedient to "seed" the market by selling new units as remanufactured ones to start the cycle of core trade-in. Unless they themselves are engaged in remanufacturing, original equipment manufacturers have little incentive to design products for ease of disassembly and refurbishing, and they are reluctant to share engineering specifications or other product data with remanufacturers. There are exceptions, of course. Some manufacturers realize that remanufacturing can enhance the reputation of their products for long life and, thereby, sales. These firms provide parts and technical assistance to remanufacturers, and in some instances may actually establish franchises for more formal cooperative relationships.

When cores arrive at the remanufacturer's plant, they are cleaned and examined to determine their condition and to identify the model and year of manufacture. Each core is then taken completely apart, and each component is thoroughly cleaned; every surface is prepared for refurbishing. All parts are continually inspected for damage or flaws that require repair or rejection. This part of the process is critical—much more so than in conventional manufacturing—since almost by definition every core will be defective in some unknown way. Even if 500 of the same parts have been found to be good, the remanufacturer cannot presume that the next part will also be satisfactory. Indeed, producing reliable products from parts of unknown quality is the greatest test of a remanufacturer's skills.

Individual components found to be flawed can be remanufactured in many different ways. Worn areas

Continued on page 28

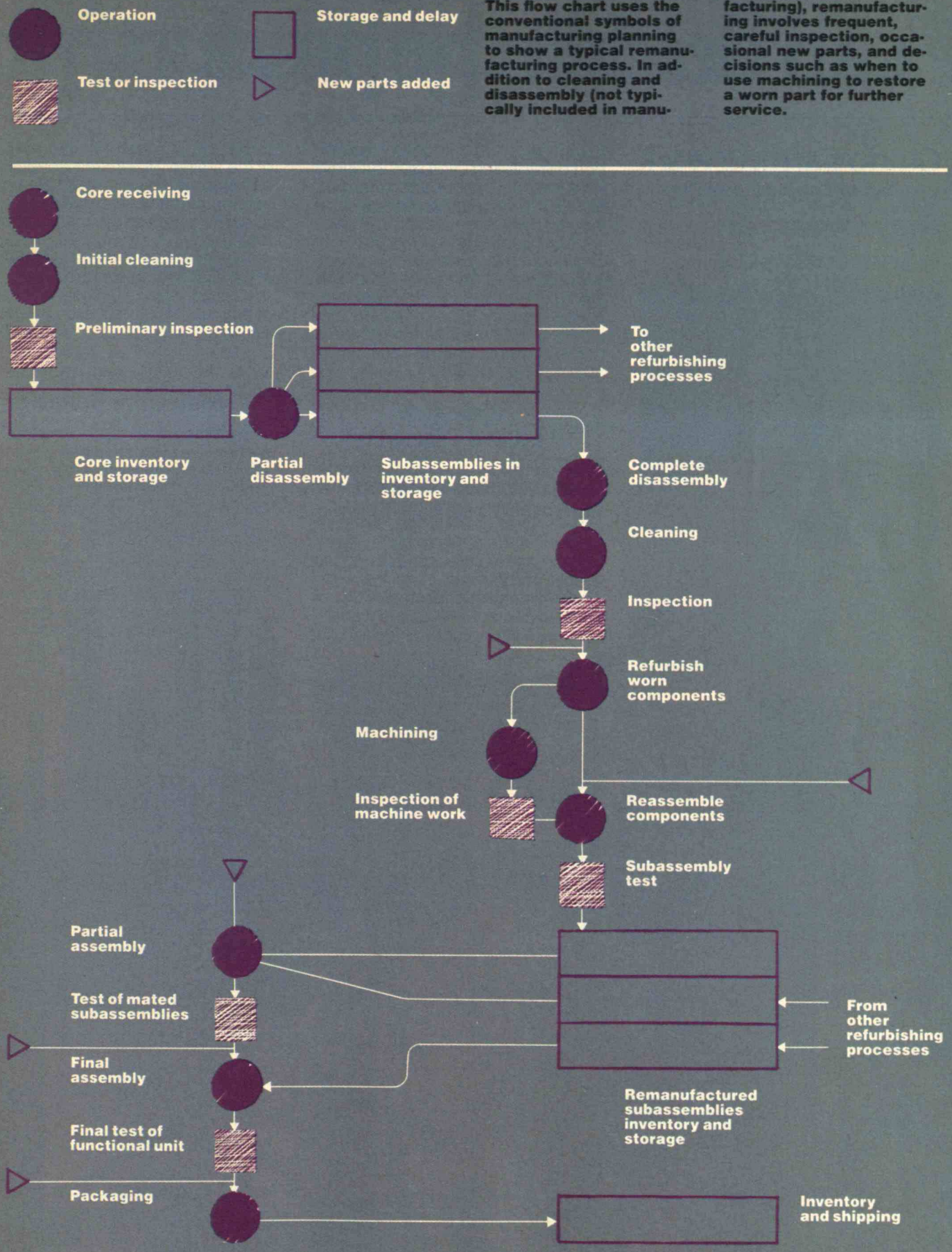
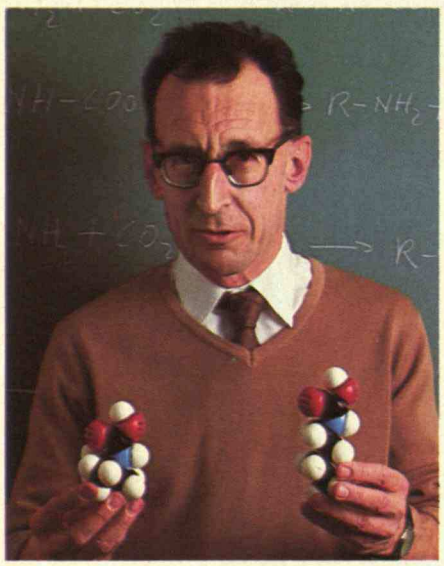


DIAGRAM: OMNIGRAPHICS

How Exxon developed can double the productivity

Guido Sartori's work on hindered amines may impact an entire industry.



Removing impurities such as carbon dioxide and hydrogen sulfide from natural, refinery, and synthesis gases is an expensive, energy-consuming process.

But at Exxon Research and Engineering Company a new chemistry discovery, and cross functional teamwork, have led to the development of a new technology—one that significantly decreases the cost and increases the capacity of commercial gas treating processes.

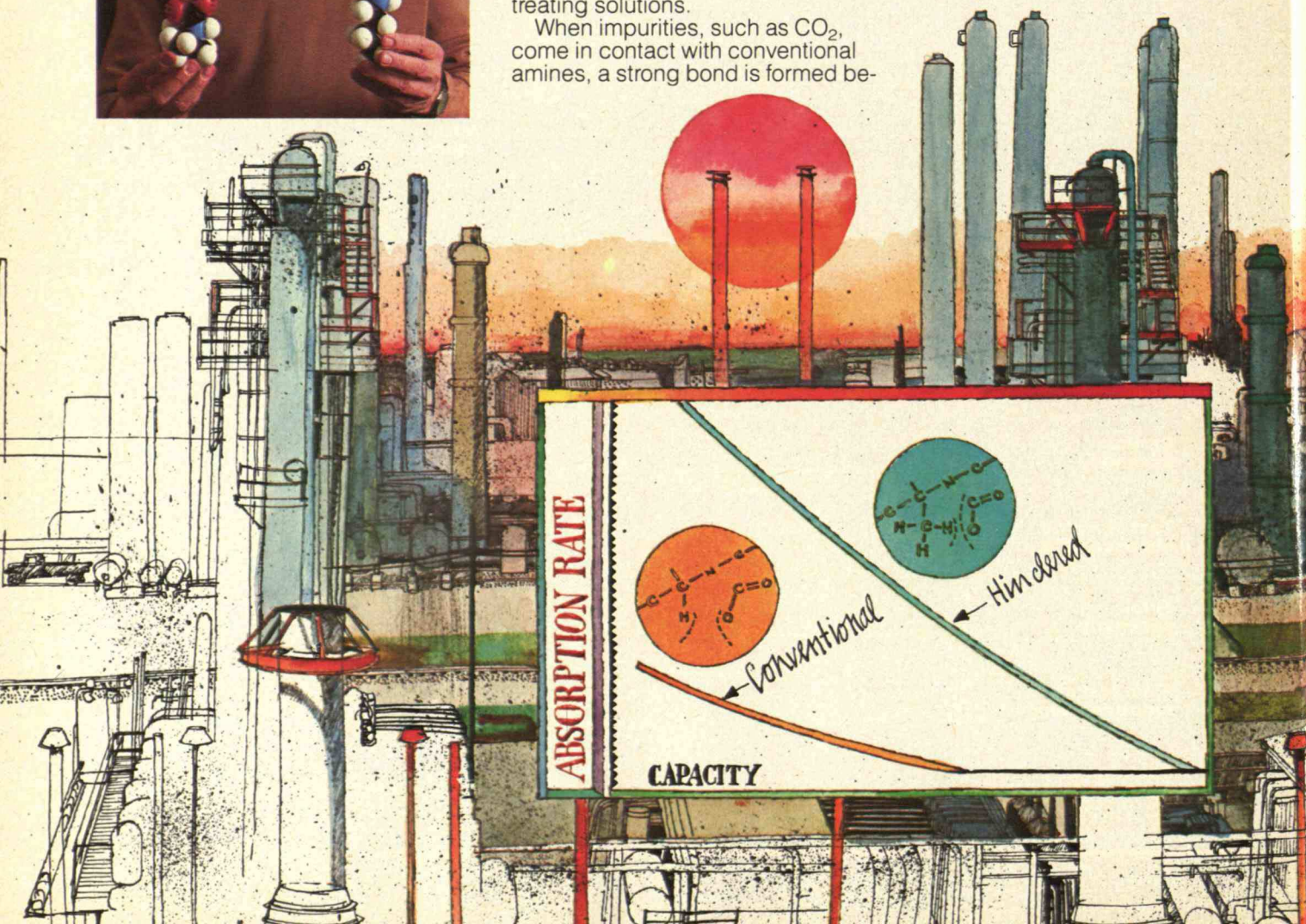
Research Led to a Discovery

Guido Sartori, a chemist in Exxon Research and Engineering Company, had been conducting research on amines—organic nitrogen-containing molecules—to increase both the absorption rate and capacity of gas treating solutions.

When impurities, such as CO_2, come in contact with conventional amines, a strong bond is formed between the CO_2 and the nitrogen atom of the amine. This strong bond ties up a disproportionate amount of useful amine. Sartori theorized that both the absorption rate and capacity of the amine would be improved if the bond at the nitrogen site could be weakened. Continuing research revealed the advantages of a whole new class of amines, which he called hindered amines.

Observing Molecular Behavior

Sartori and others began a comprehensive evaluation of the discovery, utilizing the company's advanced analytical capabilities. To understand the behavior of hindered amines, and to monitor reactions, Sartori employed the results of carbon-13 nuclear magnetic resonance spectroscopy, a



new molecules that of gas treating plants.

state-of-the-art technique not previously used for this purpose.

Further research confirmed the hindered amines' capability to substantially increase the rate and capacity of carbon dioxide absorption through the formation of low stability bonds. Low stability was achieved by placing a bulky substituent next to the nitrogen sites, thereby hindering bond formation with CO_2. Building on this new understanding, he synthesized new molecules to meet the performance requirements for specific applications.

Integrated Innovation

Other Exxon organizations joined the effort to develop improved gas treating technology. After the hindered amines had been evaluated at the laboratory bench, process development was required on a larger scale. A major pilot plant program confirmed, broadened and extended the bench scale results and helped to define the capabilities of the hindered amines. An engineering program was an integral part of the research and development required to convert these laboratory discoveries into commercially feasible technologies. Capacity increases of 50% have been achieved commercially using this technology with no added facilities.

Through integrated innovation–the combined efforts of the company's basic research, process development, and engineering staffs–hindered amine technologies advanced from scientific discovery through commercial use in less than three years. Further research has enabled ER&E to identify or synthesize other practical hindered amines.

Exxon Research and Engineering Company

Research on hindered amines is just one example of the numerous programs underway at ER&E. A wholly owned subsidiary of Exxon Corporation, ER&E employs some 2,000 scientists and engineers working on petroleum products and processing, synthetic fuels, pioneering science and the engineering required to develop and apply new technology in the manufacture of fuels and other products. For more information on Exxon's hindered amine technology or ER&E, write Dr. E. E. David, President, Exxon Research and Engineering Company, Room 707, P.O. Box 101, Florham Park, New Jersey 07932.

EXXON

This Old Volvo May Be Better Than New

BY JEANNE HERB

In 1979, Peter Fuller drove his ailing BMW into David Leggett's repair garage. Leggett inspected the car and quickly concluded that Fuller had no understanding of automobiles: the BMW was being driven with no oil in the crankcase. Leggett thereupon gave Fuller a crash course in auto care that marked the start of a friendly repairer-client relationship.

As their friendship developed, Leggett shared with Fuller his dream of someday operating a large-scale auto-remanufacturing business, and Fuller offered financial backing. At first Leggett declined, wanting to go it alone, but reality soon set in, and the two formed a partnership to open Automotive Import Recycling (AIR) as both a remanufacturing plant and an auto repair shop. The combination was short-lived, however. Their shop was too small, and "it soon became clear to us that we had to go with one or the other," Leggett recalls. They decided to go with the remanufacturing, and moved quickly to build a pioneering auto-remanufacturing business.

At this stage the experiment was more idealistic than mercenary. Leggett had been a student of environmental science at Florida State University, and had become an advocate of technologies for

At Automotive Import Recycling, Belvidere, N.J., BMWs and Volvos are stripped to the ground and their components disassembled, cleaned, refurbished, repainted, and reassembled. The result, says AIR's owners, is an old product made as good as new at about half the cost of the new.

PHOTOGRAPHS: CHRIS MAYNARD

reusing materials for ecological reasons. Leggett's experience as an auto mechanic convinced him that remanufacturing was, in fact, possible. They "simply wanted to prove the concept of rebuilding an entire automobile," he says.

Fuller and Leggett started out by purchasing 10 used cars, rebuilding them, and putting them on the market. All the 10 cars were sold, and the company began to collect orders for more—and demand from owners who sought to have their vehicles remanufactured.

Now, after four years in business, AIR has remanufactured almost 400 cars, and Leggett claims success: "We've done just what we set out to do." He says AIR is the only large-scale auto-remanufacturing business in the United States, and it's now breaking even financially. The shop has a flourishing look. The staff of 41 in Belvidere, N.J., cannot keep up with demand, and the owners are planning a major expansion.

No Part Untouched

In the beginning, Leggett and Fuller decided to work on only BMWs and Volvos for four reasons: to limit the required parts inventory; to allow workers to develop expertise in dealing with specific makes of cars; to benefit from the loyalty of BMW and Volvo owners to their cars; and to take advantage of the fact that the assembly methods used for these cars make them suitable for remanufacturing. Some other vehicles—those assembled with more bolts and fewer welds—would also be good candidates. However, AIR is sticking with BMWs and Volvos for now because the company is having trouble keeping up with even the demands in that limited range. Some 65 percent of AIR's customers are the cars' original owners. The shop handles 15 to 20 cars a month, taking from six to eight weeks to rebuild each one.

All cars being remanufactured—regardless of their condition—are disassembled down to nuts and bolts by one group of AIR workers. Each car has a wooden crate assigned to it and all of that car's mechanical parts are put inside. Some, but not many, Volvos and BMWs turn out to be beyond repair, and parts from these cars are stockpiled to be reused in other cars.

When the remanufacturing job begins, one group of workers inspects the body, another, the parts in the crate. The two groups of workers are separate—one group of body specialists and one group of mechanics. Workers typically do not switch jobs, Leggett says, because each task is so specialized that a worker requires considerable time to become adept at it.

Each part in the crate is cleaned, inspected, and tested. Some parts—such as wheel bearings, gaskets, and brake linings and pads—are routinely replaced. Of the rest, those that fail to meet strict tolerances—pistons out of round, valves warped, camshafts worn, and the like—are rebuilt or replaced, depending on their condition. Some parts that need extensive work may be set aside and rebuilt at a later date, with parts from inventory substituted. "No part is left untouched," Leggett emphasizes. Although an engine, carburetor, or transmission may be in satisfactory condition, it is still rebuilt to bring it up to new-car standards. All individual parts are given the same tests that new parts receive before being put in a new car.

Meanwhile, in the next building, the body specialists are at work on the stripped-down body and its components. Rust is scraped away and new metal (not plastic, as used in many body repairs) is welded on. Dents are pounded out, glass is removed and replaced, drain holes are cleaned, and seats and interior coverings are removed, cleaned, and repaired. Finally, the body gets a new paint job, and the interior is reassembled.

As Good as New

When completely remanufactured, each car is test-driven for about 500 miles. Then Leggett returns the as-new-or-better car to its owners, with a 12,000-mile-or-12-month guarantee and a bill that averages about $6,000. That compares favorably with the price of new Volvos and BMWs, and Leggett swears that his final product is "just as good as the new one you'll pay double for." Leggett says that, on the average, cars are returned for repairs once during the year's warranty, usually for minor work that averages one-and-a-half hours.

No innovative technologies are used in AIR's remanufacturing process—Leggett takes credit only for "combining existing ones." The lack of new technology partly reflects the fact that Leggett and Fuller had no time for research before they opened AIR's doors in 1979. Leggett thinks that research would probably yield better methods of rebuilding parts and lead to the use of less expensive materials in some parts of the remanufacturing process—such as plastics in nonstructural repairs in a trunk-seam or a floor. He thinks the company would be earning more now if it had had additional capital for R&D in the beginning. Some of what AIR workers have learned through their own initiative and in their daily work has been more costly than if it had been the result of earlier R&D.

Fuller and Leggett never intended to make substantial profits at their Belvidere facility, which is neither centrally located nor large enough to fully meet their needs. They knew, too, that they were inadequately financed. But what was only to have been a proving ground for their concept has turned into a semipermanent base from which they're now planning to move into a much larger facility. A bigger operation will allow them to purchase parts in wholesale quantities, establish assembly-line procedures to do the work more efficiently, and capitalize on the increasing demand for auto remanufacturing. AIR now has an eight-week backlog of autos awaiting remanufacture, and Leggett thinks the northern New Jersey market would support the much larger capacity he wants to achieve. □

JEANNE HERB is a student in the science writing program at New York University.

Few industrial activities other than remanufacturing can claim to turn out more embodied energy than they consume.

may be built up by welding and then machined to their original dimensions, out-of-round holes may be bored to a larger size so that an insert with the correct internal diameter can be added, bent shafts may be straightened, electrical wiring may be cleaned and reinsulated, and precision surfaces may be reground or scraped. The objective is to restore the part to its original condition, or, where the original design has led to premature failure, to rebuild or replace the part to eliminate the weakness. Most traditional manufacturing planning strategies—plant layout, process flow, inventory control, production planning, maintenance, and the like—can be applied to remanufacturing. Each conventional practice must be examined, however, to see if is it really appropriate to the different environment.

Measurement, testing, and quality-control methods used during remanufacturing are also similar to those used in original manufacture, with the one important exception that every part must be presumed faulty until proven otherwise. All employees must be trained in basic inspection techniques and motivated to maintain high quality standards. The manufacturer's reputation and success rest almost entirely upon the quality of the finished product.

Capturing Energy and Resources

The energy savings from remanufacturing can be estimated in two ways. A simple analysis shows that the energy consumed to remanufacture a product is about 60 percent of that used in making the original product. However, the *total* energy used in making a new product includes the energy cost of extracting and refining raw materials; casting, machining, and finishing each part; and assembling and testing. When all the energy embodied in a new product is added up, the total is four or five times that needed to remanufacture the same product.

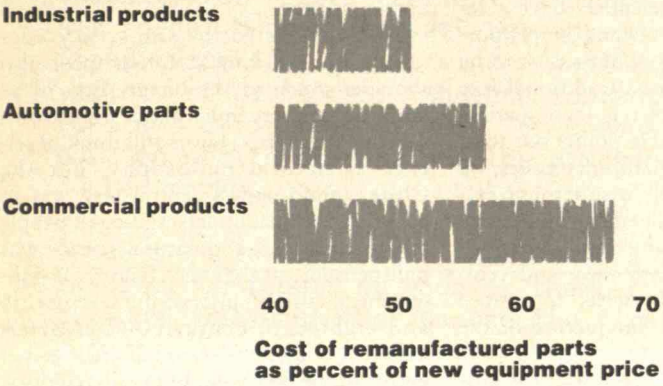
What this means is that remanufacturing can recapture much of the energy originally used in making a product at an additional expenditure of no more than 20 to 25 percent of the amount saved. Few other industrial activities can claim to turn out more embodied energy than they consume.

This result may be diminished if remanufacturing keeps in operation products such as automobiles, refrigerators, or electric motors that are less energy-efficient than their modern counterparts. But if energy is priced at its true market value, the lower price of an inefficient remanufactured product will be offset by its higher expected operating costs, and the market for that product will tend to disappear.

In addition to using less energy, remanufacturing requires much less raw material than new products, resulting in dramatic savings. Only about 10 percent (by weight) of all cores received by manufacturers are immediately rejected as obsolete or not worth remanufacturing. Another 12 to 15 percent of the original core weight is lost or replaced during remanufacture. Thus, the average remanufactured product will have about 85 percent by weight of used components. For each pound of new material used in remanufacturing, from five to nine pounds of old material are saved and reused. In a society troubled by a scarcity of energy and materials and by rising prices, these several advantages of remanufacturing are important.

Remanufacturing is labor-intensive: its processes depend on significant human input at each stage. According to our survey, about 60 percent of the required labor is unskilled or semiskilled. Some technicians, machinists, and mechanics are needed in refurbishing, testing, and inspection, but many of these higher-level skills can be acquired on the job. Cleaning, refurbishing, assembly, and materials handling require no unusual skills, and disassembly methods are also easily learned. Remanufacturing calls for only two qualities of every worker, regardless of job title: a high level of quality consciousness, and the ability to innovate. The remanufacturer faces challenges to ingenuity at every step: how to disassemble "permanently" sealed products without preventing their reuse, how to design parts to fit more than one model, how to clean an array of parts of different compositions, and how to salvage worn or damaged parts of significant value. Thus, the remanufacturing organization places a premium on people who can solve unusual problems in simple ways with whatever resources are at hand.

Of course, some situations require workers with more specialized skills. When the product is a high-technology item, such as a computer, a robot, or a valve for a nuclear power plant, skilled technicians with extensive knowledge of the product may be needed for diagnosis and processing. Some firms that are making original as well as remanufactured equipment of this kind have encouraged their most qualified technicians to move into remanufacturing jobs because of the critical need for their skills.



The average prices of remanufactured products are 55 to 60 percent of the prices of equivalent new products. The average prices of remanufactured commercial products—chiefly air compressors for refrigerators—are higher than those of other remanufactured products. This is thought to reflect the lower competitive pressures in this market, and the higher cost of used units and necessary refurbishing processes.

In general, remanufacturing employs more people of lower skills per unit of output than the original manufacturing did. It therefore makes a significant contribution to those communities where unemployment among low-skilled workers is high. Indeed, many remanufacturing operations can be located to take advantage of local labor surpluses. Remanufacturing can provide regions or even countries with experience in product and process technologies, acting as a training ground for workers and managers who can then go on into other industrial activities.

Remanufacturing also requires a relatively low capital investment, for two reasons. The expensive equipment needed to fabricate parts—metal-cutting machine tools, presses, molding machines, forges, and the like—are generally not needed in remanufacturing. Except for a few machines for cleaning, refurbishing, and testing, most remanufacturing equipment consists of hand tools, jigs, and fixtures. Working capital needs are likewise modest, because the major raw material is an inexpensive core whose cost is much lower than its economic worth.

Most U.S. remanufacturers who price their products at 40 to 80 percent of comparable new products are able to turn a good profit. The lower product prices tend to create ready markets among knowledgeable buyers.

Students of innovation and productivity sometimes wonder whether prolonging product life will dampen entrepreneurship. If remanufacturing keeps products functioning longer, will this not stifle technological change and product and process improvement? The answer seems to be that longer product life is not likely to stop innovative, "breakthrough" technology. Important improvements in the performance or cost of a service simply cannot be restrained. The durability of electromechanical adding machines, for example, did not deter the sweep of electronic calculators, nor did the durability of steam locomotives stop the transition to diesel engines. Indeed, remanufacturing may even ease the transition to new technology, particularly if major parts of the old product can still be employed. For example, microprocessor controls can be added to machines to extend their life into the era of automation. Remanufacturing may also facilitate technological change by providing a ready market for used equipment, decreasing the cost of investing in new equipment.

On the other hand, remanufacturing may discourage superficial product changes if the success of the new product suffers by competition from remanufactured units. Whether this effect occurs at all is highly dependent on the price elasticity of the market. The presence or absence of strong competition from other new-product manufacturers is likely to be a larger factor than remanufactured products in determining the role of minor improvements.

There is almost no public recognition of remanufacturing's beneficial role in our society. Indeed, current public policies tend to discourage, rather than encourage, remanufacturing. Remanufacturers themselves must be agressive in acquainting policymakers—and all Americans—with the benefits of their enterprise. If we can make our material goods last longer, we can help preserve our wealth and ensure a better standard of living for ourselves and succeeding generations. With a growing acceptance of remanufacturing as part of our way of life, we may find we have products that never die until new technology renders them obsolete.

ROBERT T. LUND is research professor of technology and policy and professor of manufacturing engineering at Boston University. Mr. Lund conducted the studies on which this article is based while at the Center for Policy Alternatives at M.I.T. under the sponsorship of the U.S. Department of Energy and the World Bank. The most recent report in the series is Remanufacturing: U.S. Experience and Implications for Developing Nations *(August 1983).*

DIAGRAM: OMNIGRAPHICS

BOOKS/CONTINUED FROM PAGE 17

elementary particles and their interactions have turned out to be intimately connected with the birth of the universe.

The concept of evolution is especially relevant to humanistic concerns because it deals with function, or biological specificity, and choice, or natural selection. Function and choice are important concepts in ethics, aesthetics, and social and political theory. Of course, scientists and humanists do not deal with these shared concerns in the same way. But their approaches can be complementary, and even synergistic, instead of antagonistic.

Postmodern Science

Toulmin has a different view of where science is and should be going. He thinks the new mission of natural science should be to "reinsert humanity into the world of nature." This will happen only if the character of the scientific enterprise is radically changed, he says. "Scientists have always to consider themselves as agents, not merely observers, and ask about the moral significance of the actions that comprise even the very doing of science." Few would disagree that scientists have a responsibility to society beyond simply pursuing research. But Toulmin seems to be saying that the scientist's traditional role of disinterested observer is incompatible with modern science. He points out that, according to modern quantum physics, we cannot measure atomic or subatomic systems without profoundly disturbing them. He thinks a new "postmodern" science—exemplified by psychotherapy and ecology—is emerging that seeks to restore "human meaning" to our picture of the natural world.

Unlike Toulmin, I believe that the natural sciences can provide a comprehensive and emotionally satisfying view of the world. Why, then, does modern science, which addresses the same questions as religion concerning the origin of the world, often seem so irrelevant to human concerns? Although science and technology have transformed our lives, they have made only superficial changes in the way we view the universe and ourselves. In a recent poll, more than half of the respondents accepted the theory of evolution, but most considered the process to be under divine guidance.

The fault lies partly with science education, but working scientists must also shoulder much of the blame. Few of us know or care very much about science outside our specialties; fewer still think of science as natural philosophy. For the Greeks, philosophy's central task was to achieve a rational understanding of people and the universe, and natural science was indispensable to that task. The great philosophical cosmologists of the seventeenth and eighteenth centuries—Descartes, Leibnitz, and Kant—were all creative scientists of the first rank. But in this century, philosophers have tended to define their subject in ways that make natural science nearly irrelevant to it, while scientists have just as conscientiously refrained from discussing the implications of science for human philosophical issues. And so philosophical cosmology has languished—and will continue to languish until philosophers become scientists, or scientists become philosophers. □

David Layzer is Donald H. Menzel Professor of Astrophysics at Harvard.

LETTERS/CONTINUED FROM PAGE 5

mains preoccupied with military programs to the exclusion of the major educational, economic, and technical initiatives necessary to move successfully to an information-based economy. The result can only be deteriorating economic performance and increasing social dislocation.

Conserving Energy

I suggest that Bernard Frieden and Kermit Baker (*"The Record of Home Energy Conservation: Saving Bucks, Not Btu's," October, page 23*) assess the progress of the commercial, industrial, and transportation segments in conserving energy. They state that nothing in recent experience supports an estimate "that the United States could cut its energy consumption by 30 to 40 percent through conservation." Yet microprocessor-based energy-management systems, housekeeping measures, cogeneration, waste-heat recovery, and energy-efficient equipment have been widely adopted in the commercial and industrial sectors. Similarly, the transportation sector has quickly transformed the automobile stock by introducing much more energy-efficient vehicles. Thus, although the residential sector has not reduced total energy use at all since the 1973 Arab oil embargo, the commercial, industrial, and transportation sectors have made considerable strides in conservation.
Stuart D. Brager
San Jose, Calif.

I enjoyed the authors' hard-hitting article. However, I disagree with their emphasis on the negative impact of energy conservation on "living standards." They are right in saying that the measures taken to conserve energy have in some cases decreased safety and affected health. However, cooler wintertime thermostat settings can improve lifestyles, and people differ in their individual heating needs.

For example, lower temperatures mean higher relative humidity levels in living spaces. When outside air at 30°F and 80 percent relative humidity is heated to 75°F for indoor living, the relative humidity is about 14 percent. This leads to cracked lips, dried mucous membranes, and colds. Lowering the thermostat to 65°F increases relative humidity to 23 percent, which is near the lower limit of human comfort.

Policymakers and energy professionals must carefully consider their role in socially conditioning citizens about energy. If we write that setting back thermostats means degrading lifestyles, we reinforce negative attitudes. Instead, I suggest we find more sophisticated ways to promote conservation so that people can be empowered to make informed and intelligent choices among complicated and highly personal trade-offs.
John A. Carlton-Foss
Lincoln Center, Mass.

(Letters continued on page 59)

SCIENCE/SCOPE

Tests of a prototype ducted rocket engine hold promise of increased range and velocity for future tactical missiles. In milestone demonstrations for the U.S. Air Force, Hughes Aircraft Company solid-propellant ducted rocket engines were fired successfully in a wind tunnel simulating supersonic missile speeds at a variety of altitudes. Whereas conventional air-launched motors contain all the fuel and oxidizer they need for combustion, the ducted rocket obtains a large portion of its oxygen from the atmosphere. An important benefit is that the ducted rocket motor can contain more fuel for a given weight.

Space shuttle crews will soon be able to rendezvous with satellites in low orbit in order to repair or recover them, thanks to a new integrated radar and communications subsystem that passed its first tests on the shuttle last June and August. The Hughes subsystem, also called a Ku band radar, has an antenna dish at the front of the cargo bay. It can pinpoint objects as small as 1 square yard from up to 14 miles away. If the object is equipped with an electronic signal enhancer, the range increases to 345 miles.

NATO early-warning aircraft are being equipped with a communications system that uses four primary encoding techniques to hamper enemy eavesdropping or jamming. The Joint Tactical Information Distribution System (JTIDS) provides E3A AWACS aircraft and NATO ground command centers with secure voice and digital communications. One JTIDS encryption technique is spread spectrum, in which a signal is expanded over a large bandwidth. With frequency hopping, a second method, frequencies are changed many times a second. Another technique, time division multiple access, assigns certain users to specific time slots no longer than a fraction of a second. Finally, to verify messages, JTIDS repeats messages automatically. Hughes is supplying JTIDS to NATO and the U.S. Air Force.

More than $18 million in funds and equipment has been pledged to the University of California at Berkeley by a group of computer and microelectronics firms for research in computer-aided design of microelectronics circuits. A major goal of the expanded research and teaching center will be to improve computer systems that will aid design engineers in the creation and test of highly complex circuits containing hundreds of thousands of transistors. Each of the contributing firms, including Hughes, will have the opportunity to send a researcher to work with faculty and graduate students in the campus facility.

A system that provides three-dimensional positioning information to military field commanders is in production. The Position Location Reporting System (PLRS) gives commanders continuously updated information on the location of troops, vehicles, helicopters, fixed-wing aircraft, and weapons. The system links small portable radios into a network controlled by microprocessors. Users can locate their positions, navigate to predetermined positions, and be informed when nearing or crossing boundaries. Join our high-tech team. Send your resume to Hughes Ground Systems Group, Employment Dept. SE, P.O. Box 4275, Fullerton, CA 92634.

Helping engineers change gears.

The relentless ingenuity of America's engineers has made technological revolution commonplace.

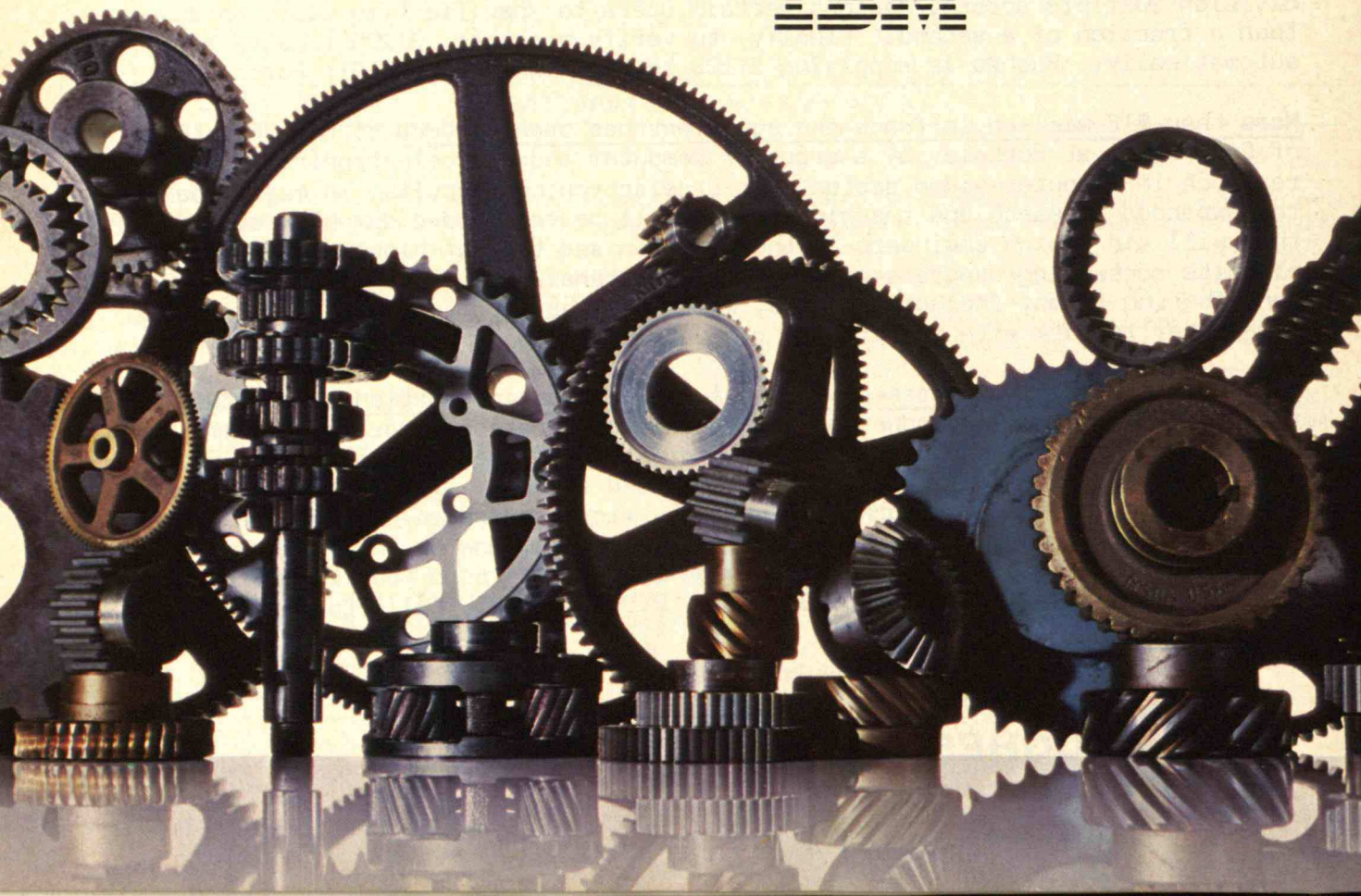
But today, manufacturing engineers face a relentless challenge: to produce goods of ever-higher quality at ever-lower cost. The marketplace, domestic and foreign, demands it.

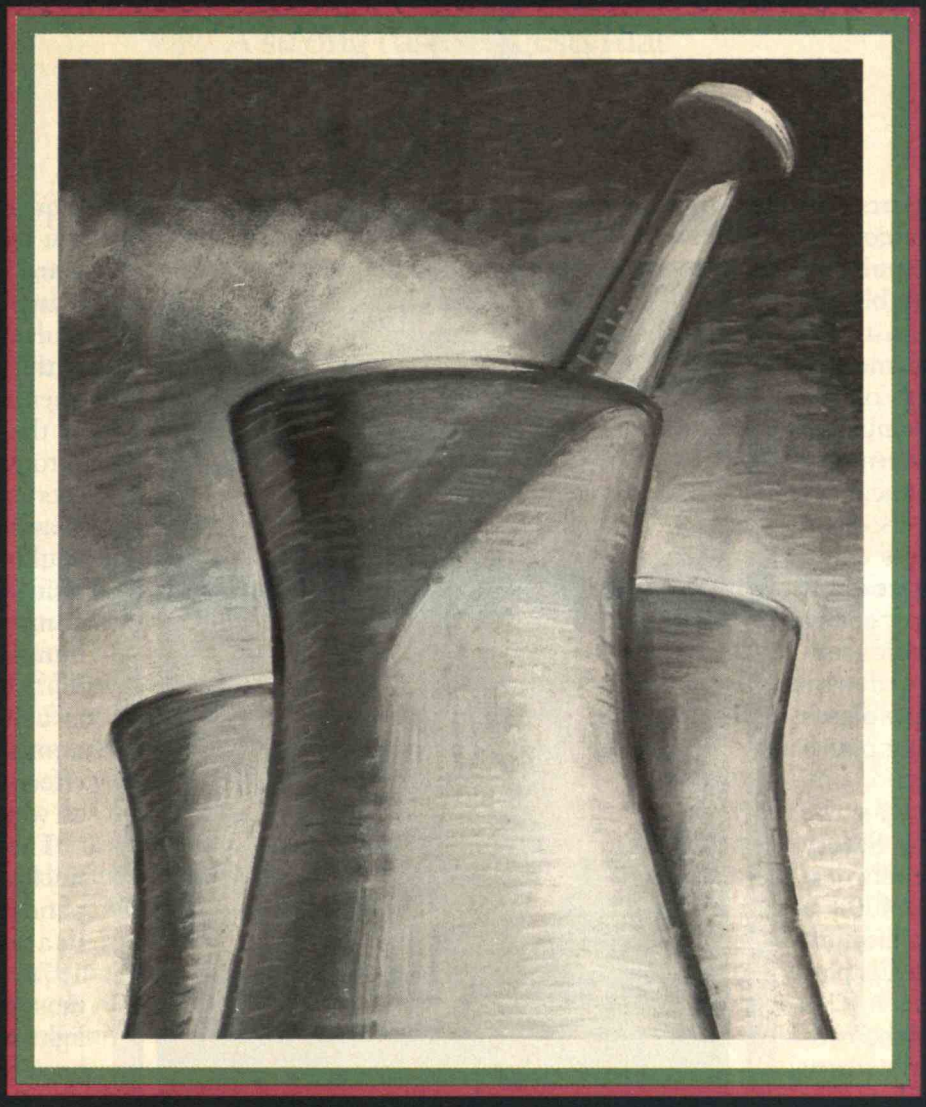
To meet that challenge, engineers need state-of-the-art training and state-of-the-art tools. This, of course, is a job best done by America's universities. But universities can't do it alone. All sectors of society must help.

That's why IBM is giving $50 million in money and equipment to 22 universities for the creation and expansion of engineering programs in manufacturing systems. The curricula, in part, will include computer-aided design and manufacturing, robotics and lasers, quality control, systems management, and automation.

We expect this investment in education to pay off by helping to keep America's manufacturing in high gear.

And that will pay off for all of us. IBM®

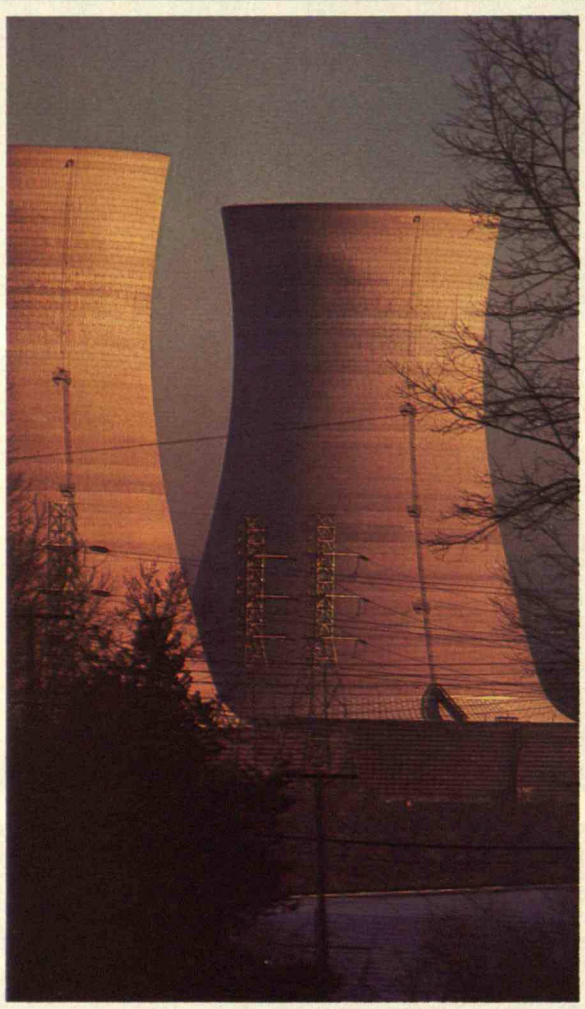




R_x for Nuclear Power

Five years ago, on March 28, 1979, the accident at Three Mile Island's unit 2 struck a near-lethal blow at the already ailing U.S. nuclear industry. No new reactors have been ordered since then. And studies prompted by the accident have revealed major flaws in a number of other plants, both under construction and in service. The incident and its aftermath have raised two vital questions: Can regulators realistically measure the potential risks of civilian nuclear power plants? Can the industry build a new generation of reactors that are inherently safer than present ones? Technology Review *examines both questions in this special anniversary section. The first two articles express different views on the value of probabilistic risk assessment, the method now used by the nuclear establishment to estimate the chances of accidents that have not happened. The final three articles report preliminary conclusions of a major study on approaches to new, safer reactors.*

ILLUSTRATION: WILLIAM HARSH



Finessing the Risks of Nuclear Power

BY JAMES J. MacKENZIE

TWELVE years ago the Atomic Energy Commission faced an unenviable dilemma. It had just suffered through 22 months of public hearings on the safety systems of nuclear power plants, embarrassed by the paucity of data supporting its claim that nuclear plants could survive loss-of-coolant accidents without a major release of radioactivity. How could the agency license new plants or allow operating plants to keep running?

The answer was the massive Reactor Safety Study (RSS, officially designated WASH-1400), a three-year, $4 million effort. From the AEC's perspective, the RSS produced the "right" answers. One needn't worry excessively about the consequences of nuclear accidents, the report concluded, because the analytic underpinning of the RSS—probabilistic risk assessment—showed that serious accidents were extremely unlikely.

Probabilistic risk assessment (PRA) is a computer-based technique that uses so-called "event-tree" and "fault-tree" analysis to piece together possible accident scenarios. Event-tree analysis begins with a failure of a specific component (an "event"), such as a pipe rupture or valve failure. The possible consequences of that event are then projected forward in time through the plant systems. Similarly, fault-tree analysis begins with an assumed consequence (the "fault"), such as the meltdown of a reactor core, and then projects backward in time to examine the events that could lead to the fault. Using *estimated* rates for component failure and human error, the *probability* of serious accidents is calculated. The economic and public-health effects can be projected as well.

The use of PRA in the nuclear industry has expanded greatly since publication of the RSS in 1975. About 20 PRAs on most designs of operating light-water reactors have been completed. The Nuclear Regulatory Commission (NRC) has sponsored PRAs on specific plants to evaluate the need for safety improvements, and utilities have conducted PRAs in an effort to show that their plants are safe enough. The NRC is also using PRA to set its research and regulatory priorities. And most important, the NRC will use PRA to determine whether its new "safety goals" for nuclear plants are being met. These are numerical guidelines for the maximum risks that nuclear plants may pose to individuals and society.

PHOTOGRAPH: OWEN FRANKEN, STOCK BOSTON

A strong case suggests that probabilistic risk assessment's key role in shaping policy is unjustified.

Probabilistic risk assessment has clearly arrived. It is now the most important policymaking tool available to the NRC, aside from that old workhorse "engineering judgment." But is PRA up to the tasks it is being used for? A strong case suggests that it is *not*—and that its key role in shaping policy is unjustified.

Data Difficulties

Criticism of the Reactor Safety Study and its PRA techniques appeared quickly. The American Physical Society (APS) published the first prominent review of the draft RSS report in 1975. The APS study group, chaired by Harold Lewis, professor of physics at the University of California, concluded that "the event-tree and fault-tree approach can have merit in highlighting relative strengths and weaknesses of reactor systems. . . . However, based on our experience with problems of this nature involving very low probabilities, we do not now have confidence in the presently calculated absolute value of the probabilities." Unfortunately, the APS study resulted in few substantive changes.

In August 1977, the Union of Concerned Scientists published a book-length review of the final report, concluding that the assertions of the RSS on nuclear risks were suspect. The use of PRA was especially criticized, and many of the problems plaguing the method remain today:

☐ Much of the elementary data on the reliability of plant components were incomplete, uncertain, or unavailable—leading to major uncertainties in the risk estimates. Also, the data covered only about one year's operating experience at just 17 nuclear plants. Such a limited data base is inadequate for estimating rare events that could result in serious accidents, or for assessing possible failures that could result from aging. Moreover, some failure rates used in the RSS—such as those of diesel generators and high-pressure coolant systems—appear to be indefensibly optimistic.

☐ For most of the RSS analysis, failure of one component was assumed to be independent of failures of other components. "Common-mode" failures, in which a single event can simultaneously disable redundant safety equipment, were largely ignored. However, experience has proven that they shouldn't be. For example, a common-mode failure twice triggered serious incidents at the Salem nuclear plant in New Jersey in February 1983. Because of sloppy plant maintenance over several years—a "failure" of management, in this case—two circuit breakers, either of which should have been able to shut down the plant automatically, failed simultaneously. The NRC had previously stated, on the basis of PRA analysis, that there was only a 1 in 33,000 chance that the reactor would fail to "scram" automatically. Yet such an event occurred twice—within one week—representing a failure rate of about 1 in 1,800.

☐ The RSS generally assumed that current reactor designs were adequate, thus overlooking possible intrinsic design deficiencies. For example, considerable controversy surrounded the emergency core-cooling systems. Critics cited the lack of testing under accident conditions and unanswered questions about possible design flaws that could debilitate the cooling systems. But the RSS relied on industry predictions about the effectiveness of the cooling systems. The study also assumed that nuclear plants are built according to plan and are properly operated. Yet numerous recent events suggest this isn't always the case. For example, a mixup in blueprints led to improper installation of earthquake safeguards on a reactor at the Diablo Canyon plant in California. And at the Pilgrim plant in Massachusetts, the automatic system that would prevent combustion of hydrogen gas in the containment structure surrounding the reactor following an accident was found to be inoperative for several years.

☐ The RSS was lax in addressing major problems that contribute to nuclear risks, such as aging and degradation of plant components, earthquakes, and sabotage and terrorism. Consider the possibility of what's called "pressure-vessel" rupture. The pressure vessel in a pressurized-water reactor is a steel cylinder, typically 40 feet high, with an inside diameter of 14 feet and walls 8 inches thick. The fuel core, weighing about 100 tons, is contained within the pressure vessel. If this vessel ruptures, radioactive decay heat cannot be removed from the core and a meltdown will result. The RSS concluded that the risk of such a failure was "negligible." Yet the metal walls of early types of pressurized-water reactor vessels can become brittle with age, and the resulting danger of overpressurization and vessel failure remains a serious unresolved issue for many of these older reactors.

☐ Because it is not possible to identify all accident sequences, the absolute values of the calculated risks

Despite considerable controversy, the NRC is hooked on using PRA numerical estimates in its day-to-day planning and decisions.

in the RSS had very large uncertainties. This intrinsic shortcoming of PRA was clearly demonstrated in the space program, where fault-tree analysis was extensively employed. Many of the failures—almost 35 percent of the in-flight malfunctions—had not been identified by the method as "credible."

Risk Estimates "Not Reliable"

Still more criticism came from a group appointed by the NRC to judge the achievements and limitations of the RSS. In September 1978, the Risk Assessment Review Group reported that the RSS was a "substantial advance" over previous assessments of reactor risks, but group members could not determine whether the RSS accident probabilities were too high or too low. The group said that the error bounds were "greatly understated . . . in part because there is in many cases an inadequate data base, in part because of an inability to quantify common-mode failures, and in part because of some questionable methodological and statistical procedures."

NRC then issued a policy statement retracting its endorsement of the RSS risk estimates: "The Commission does not regard as reliable the Reactor Safety Study's numerical estimate of the overall risk of reactor accident."

Despite the controversy, the NRC is increasingly hooked on using PRA numerical estimates in its day-to-day planning and decisions. No better illustration exists than the agency's new "safety goals," which represent a landmark in NRC's decision-making process. The first goal is that the risk of a prompt fatality to a person near a nuclear plant, as a result of an accident in that plant, should not exceed 0.1 percent of the sum of the risks from all other kinds of accidents. Second, the risk of cancer death to people within 50 miles of a plant as a result of radiation from accidents or normal plant operation should not exceed 0.1 percent of the risks from all other causes of cancer. Third, the chance of a large-scale core-meltdown accident should normally be less than 1 in 10,000 per reactor year. And finally, in deciding whether a safety change is necessary, a cost-benefit guideline of "$1,000 per person-rem averted" should be employed.

PRA is the only analytical tool available to determine compliance with the new goals. And NRC Chairman Nunzio J. Palladino intends his agency to use the "bottom-line" estimates provided by PRA to justify important cost and design trade-offs for nuclear plants now operating. His motivation seems clear—to avoid new safety requirements in existing plants. "I believe it essential," he acknowledged in 1982, "that we get control of the issuance of greater numbers of regulatory requirements on plants that are now operating or soon will be operating. In short, I want to prevent unnecessary backfitting."

The NRC's application of PRA and the new safety goals will apparently vary according to the situation. "Because of the uncertainties inherent in PRAs, one must be cautious in making absolute comparisons between a risk estimate for a plant and one of the safety-goal design objectives," says the NRC in a January 7, 1983, statement. "If, for example, such a comparison indicates that a design objective is not met, one would expect the next step would be to examine the underlying technical reasons."

That seems a reasonable process. But the statement continues: "The timing of any corrective actions, if needed, would depend on factors such as the estimated magnitude of the risks involved, the need for power, the number of plants involved, the cost of replacement power, and the available industry and NRC resources." The message: deliberation and weighing of the costs to the utilities are in order if PRA indicates that a plant does not meet the safety design criteria.

On the other hand, if plants do meet the safety goals, a markedly different NRC attitude prevails. According to the agency's statement, "Where there is a reasonable judgment that the public risk and core-melt frequency design objectives actually are met for current plants, benefit-cost evaluations should not be performed to justify plant design modifications that further reduce risk." In other words, no further safety improvements are to be considered—even though PRA's "uncertainties," NRC admits, should signal caution.

Caught in the Shuffle

This fast shuffle has not gone unnoticed. It has been center stage in several memoranda to the NRC from its own safety watchdog, the Advisory Committee on Reactor Safeguards. In June 1982, the ACRS advised the NRC not to adopt the safety goals until a better means of showing compliance could be developed. Indeed, the ACRS was unusually candid: "The large uncertainties inherent in PRA are well

Public—and investor—confidence in nuclear power was the principal victim of the accident at Three Mile Island in March 1979. Here, demonstrators in Harrisburg, Pa., mark the first anniversary.

Using probabilistic risk assessment to determine the likelihood of reactor accidents will not by itself restore confidence: only a long period of safe operation can achieve that goal. This means the nuclear industry must correct many persistent technical and human problems.

recognized and are acknowledged in the proposed policy statement. These uncertainties make the use of PRA in decision making (which occurs already within the NRC) subject to large differences in the results obtained by different groups of analysts for the same accident scenarios. These uncertainties also permit abuse of the methodology to obtain a result which supports a predetermined position by selective choice of data and assumptions."

In September 1982, ACRS members Myer Bender and Jeremiah Ray (the latter now chairman of the ACRS) sent a scathing critique of the safety goals to NRC Chairman Palladino. "There is no way," they wrote, "in which the currently proposed safety policy goal will serve any useful public safety purpose as long as its main assessment basis is PRA." The memo continued: "The well-established 'inscrutability' of the WASH-1400 (RSS) results was primarily a consequence of the thin and generally unvalidated data base used to establish event probability. These data from WASH-1400 are still being used in PRAs with very little discretion concerning their validity. Hardly any new data are available."

After enumerating a number of shortcomings of PRA techniques, Bender and Ray observed that "PRA studies as currently performed will remain inscrutable and will, at least for the next decade, be little more than a display of logical thought based on essentially arbitrary reliability assumptions." The ACRS members criticized PRA techniques with blunt language rarely seen in government memos: "The claims for PRA concerning its ability to assess public-safety risks are little more than a sham that will hide the fact that the basis for safety will always depend upon the judgment of a few individuals."

The American Nuclear Society has also expressed strong reservations on the use of PRA in connection with safety goals. In a January 1983 letter to the NRC, the society said it did consider PRA to be an extremely powerful tool. "However," it continued, "it is also necessary to fully appreciate that at the current state of the technology PRA is also a very imperfect tool. Large differences in the results can come from different groups performing the analysis. Uncertainties exist from all of the following: determination of the dominant risk paths; accident phenomonology; the data base characterizing system failure; the treatment of common-mode failures and of human factors; and more generally in the various assumptions underlying the PRA analysis."

PRA and Public Opinion

In the face of so much technical criticism, why do the NRC and the nuclear industry continue to rely so heavily on PRA? There are several reasons, some technical and some political. The technical reasons are fairly straightforward. PRA has some value for locating weak points in specific power plants—equipment or human weaknesses that could lead to

PHOTOGRAPH: COWELL, BLACK STAR

Three Mile Island showed that utilities owning nuclear plants face enormous economic risk. The reactor remains out of operation, while the cost of cleanup and repairs has reached into the billions of dollars. Far left: The last load of radioactive waste leaves in August 1983. Left: A worker prepares to enter the reactor containment building. Above: The plant's control room looks nearly the same today as it did the day of the accident.

serious accidents. And there is general agreement that PRA can help identify some of the more serious pathways to accidents.

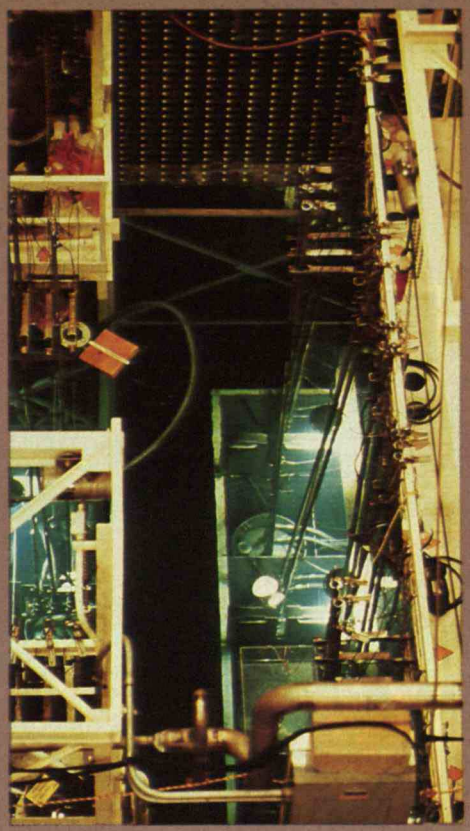
The political reasons are far more tenuous. The use of PRA to yield absolute probabilities for accidents stems from the industry's need to survive. Nuclear advocates understand that restoring public confidence—the principal victim of the accident at Three Mile Island—is essential to the expansion of nuclear power. Though it had a minimal impact on public health, the TMI accident had a profound impact on the viability of the nuclear industry. The incident graphically showed that utilities owning nuclear plants are at enormous economic risk. As the *Wall Street Journal* put it, "Nuclear power is a business that can lose $2 billion in half an hour."

Since TMI, other events have shaken public—and investor—confidence in nuclear energy. The Oak Ridge National Laboratory released a report in July 1982, in which it reviewed nuclear incidents between 1969 and 1979 to determine the likelihood of serious accidents. Of the thousands of events analyzed, the report concluded that 169 were serious enough to be potential contributors to severe core-damage accidents. The report then went on to estimate the chances that these incidents might lead to severe core damage. The conclusion: chances were between 1 in 222 and 1 in 588 per reactor-year of operation, a much higher probability than cited in the Reactor Safety Study. The industry-backed Institute of Nuclear Power Operations quickly claimed that the Oak Ridge techniques were faulty, and that the use of PRA would show substantially smaller probabilities for accidents.

Oak Ridge has since updated this study, publishing a draft report in July 1983 covering nuclear incidents in 1980 and 1981. The report concludes that the chance of a severe core-damage accident happening as a result of these incidents was 1 in 4,000 per reactor-year of operation. According to Robert Minogue, NRC research director, while the likelihood of a severe accident "probably has decreased . . . the amount of decrease cannot be quantified with much confidence." However, even at this "improved" frequency rate, there is still a roughly 10 percent chance that a severe core-damage accident will happen in the next five years.

Another controversy ignited in November 1982. The Sandia National Laboratory released its report on the possible consequences of accidents at 91 reactor sites in the United States. At the same time, Rep. Edward Markey of Massachusetts released the supporting figures showing the results of "worst-case" accidents at the sites. These figures indicated that, for example, 100,000 persons might die within a year from a worst-case accident at the Salem plant

The weeks following the TMI emergency saw a flurry of action, political as well as technical. Although the pace is less frantic, activity at the plant continues and the accident reverberates through the industry. Far right: The "submerged demineralizer" has decontaminated 600,000 gallons of radioactive water and is still at work. Right: President Carter tours the stricken plant. Below: Area residents camp out in an evacuation center in Hershey, Pa.



in New Jersey, or that property damages might reach $300 billion in the area near the Indian Point plant in New York. The NRC countered by arguing that, according to PRA, such accidents are extremely unlikely—1-in-a-billion longshots. The utilities that own the Indian Point plant sponsored a PRA that backed up the NRC's position. They said the probability of an accident's happening at Indian Point that would kill one person immediately (not a "worst-case" accident) is only 1 in 1.7 million years of operation.

However, given the siting and technical problems at Indian Point and many other plants, the industry and its federal overseers are using PRA to convey a sense of security to the public that cannot be justified. The unambiguous lesson of the RSS reviews and the skepticism of the ACRS is that the likelihood of serious accidents cannot yet be precisely determined. Recall that the types of accidents occurring at TMI and at Browns Ferry, Ala., in 1975, were officially deemed "not credible."

PRA's dual role as both a technical design tool and an instrument in setting public policy will surely continue. Clearly, PRA can provide insights into how to make new plants safer than existing ones, and existing plants safer than they might otherwise be. It also has value in identifying areas for improving the training of operators and the maintenance of important safety equipment. But in the public-policy debate, PRA by itself cannot restore confidence in nuclear power; only an extended period of accident-free operation can achieve that goal. The nuclear industry's problems are real, not just the creation of critics. They include persistent mechanical problems ranging from poorly designed valves to cracking pipes and leaking steam generators; poor quality control in plant construction, resulting in skyrocketing costs and unreliable operation; and, not least, inadequately trained plant operators.

The nuclear industry has an opportunity to solve these problems, because, ironically, there will probably not be any orders for new plants during the 1980s. In that lull, the industry could try to develop a few safe, standardized plant designs. It could upgrade the management of plant construction. And, importantly, it could work to correct the persistent technical and human problems plaguing reactors in operation. Completing these meticulous, unglamorous tasks could provide nuclear power with a new lease on life. Failure to do so will surely hasten its demise, a course that probabilistic risk assessment will be unable to change.

JAMES J. MACKENZIE is a senior staff scientist with the Union of Concerned Scientists. He holds a Ph.D. in nuclear physics from the University of Minnesota, and was senior staff member for energy on the President's Council on Environmental Quality from 1977 to 1981.

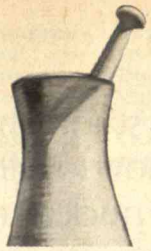
PHOTOGRAPHS: GPU NUCLEAR CORP.; ROBIN MOYER AND R. M. OWEN, BLACK STAR

Probabilistic Risk Assessment: Identifying the Real Risks of Nuclear Power

BY SAUL LEVINE

Working in a simulator, a technician learns how to deal with operating problems in a nuclear reactor. The technique of probabilistic risk assessment enables engineers to determine the real hazards that arise from different operating problems.

PHOTOGRAPH: MITCH EPSTEIN



PROBABILISTIC risk assessment—a method of predicting the likelihood and consequences of reactor accidents—has come of age. PRA studies have been completed on some 20 reactors, including the Indian Point plant in New York, the Zion plant in Illinois, and the Limerick plant in Pennsylvania. These studies show that nuclear reactors pose very small risks to the public. More important, PRA provides fundamental insights into which factors are truly significant in reactor safety and which are not. This technique is already being used by some utilities to assess the safety of their reactors, and by the Nuclear Regulatory Commission (NRC) to formulate more effective regulations.

PRA provides fundamental insights into which factors are truly significant in reactor safety and which are not.

The heart of PRA is contained in logic models known as event trees and fault trees. Event trees describe initiating events such as pipe breaks, and subsequent successes or failures of the systems designed to cope with them. They contain accident sequences that could cause the nuclear fuel to be severely damaged, and the subsequent processes that could damage the containment building and release radioactivity to the environment. Fault trees describe the ways in which the systems involved in the accident sequence could fail, and provide estimates of the frequencies of such failures. The fault trees use data on failures of components and human errors to predict the probability that a complete system will fail. Event trees and fault trees are widely accepted as valid analytical tools by the technical community. Hence, by combining the two in a PRA, analysts can properly use available data on rates of failure to predict events that, because of their low frequencies of occurrence, have not happened.

The traditional "deterministic" approach to reactor safety has served well for many years, but it often masks the important issues. That approach is based on evaluations of a list of "design-basis" accidents—potentially serious malfunctions or accidents selected on the basis of engineering judgment over decades of experience. For example, one of these accidents supposes that the largest pipe carrying water as a coolant to the reactor core suffers a "double-ended" rupture: water flows freely from both sides of the break. Reactors must have emergency systems to cope with this and other design-basis accidents without harming the public. The deterministic approach has thus provided reactors with many safety systems that, in fact, have the capability to deal with accidents far more severe than the design-basis ones. However, the deterministic approach, since it is principally judgmental, cannot clearly define the risk significance of the many factors involved in the safety of a nuclear reactor.

PRA logic models go beyond normal regulatory thinking to define situations in which engineered safety features can fail and cause significant public risk. Also, PRAs consider such items as multiple failures of reactor components and natural events such as earthquakes more severe than those considered in the licensing process. PRA models additionally provide a structure in which engineers can quantitatively assess failures in systems, components, and human judgment that stem from common causes.

PRA thought processes and logic structures effectively force attention onto issues genuinely important to risk. In a regulatory context, this fact can be used to help make regulatory requirements and processes more consistent and rational.

PRA at Work

These concepts can be illustrated by a few examples. The first came in 1975, after the Nuclear Regulatory Commission published the Reactor Safety Study known as WASH 1400, which contained the first detailed application of PRA to reactor safety. Four staff members argued that the NRC was not adequately handling 15 issues that were allegedly important to safety. It took a few days to understand the issues. But once they were understood, the PRA analyses took only a few minutes each.

The issues fitted into three categories. Five related to procedural matters that had no safety impact on reactors. Some of the remaining ten involved accident sequences that led to very small releases of ra-

Enough studies have been completed by now to tell us that the risks from predicted nuclear reactor accidents are quite small.

dioactivity into the environment; because they would result in negligible impacts on public health, they were of insignificant concern to public safety. The remaining items related to accident sequences with significant potential releases of radioactivity. But PRA thought processes showed that the items of concern could not affect the outcome of the accident in any substantial way.

This example typifies a situation in which the normal regulatory thought processes could not answer technical concerns. Because similar situations have not been clarified in the past, thousands of engineers in utilities, reactor vendors, architect-engineering firms, and the NRC are still spending needless time and effort on issues that seem important to safety but which in fact are not important. PRA can help to reduce this wasted effort.

As the next example shows, systems that meet NRC regulations can still be inadequate from the perspective of risk. NRC sponsored a quantitative study using fault trees of the reliability of auxiliary feedwater (AFW) systems for 25 different pressurized-water reactors. PRA studies had demonstrated the importance of the systems, and the accident at Three Mile Island unit 2 reinforced this insight. The agency found wide variation in the reliability in different plants and showed how the systems' reliability could be improved. The NRC judged a large number of these systems unreliable enough to require immediate improvements, and these improvements were made.

Another example relates to unresolved safety issues. Since the mid 1960s, 133 of those issues have arisen in the NRC's licensing process. But a one-month analysis using probabilistic techniques showed that only about 20 of the cases had any real significance for safety.

Limitations and Uncertainties

PRA techniques have some well-defined limitations. They cannot evaluate certain problems or issues, such as sabotage, diversion of nuclear material, and detailed design of components. Also, PRA techniques are not yet fully mature in many areas, such as analysis of human errors; new models are evolving continuously and will improve future PRAs.

Because of imprecisions in such items as the data on failure of equipment, human error, and the modeling of unlikely physical processes, the uncertainties in PRA estimates are quite large. Many engineers and others find this fact disconcerting. Their concern probably arises because they are not used to seeing calculations that indicate their uncertainties on paper. But in fact almost all engineering calculations do contain uncertainties that are generally not displayed. However, the uncertainties in PRA estimates are generally larger than those in other engineering calculations; and they will likely continue to be so because of the need to describe and quantify the likelihood of events that have not happened and are unlikely to happen.

The real question is whether the results of PRA are useful, even with their associated uncertainties. The answer is a resounding yes—because the principal engineering and safety insights gained by PRA are usually not significantly affected by uncertainty, and because in any case these insights cannot be derived in any other way. It is also important to recognize that these insights are gained principally by using the quantitative aspects of PRA to separate what is important to safety from what is not. In the normal, qualitative, regulatory thought processes, those lines are blurred.

What We Have Learned

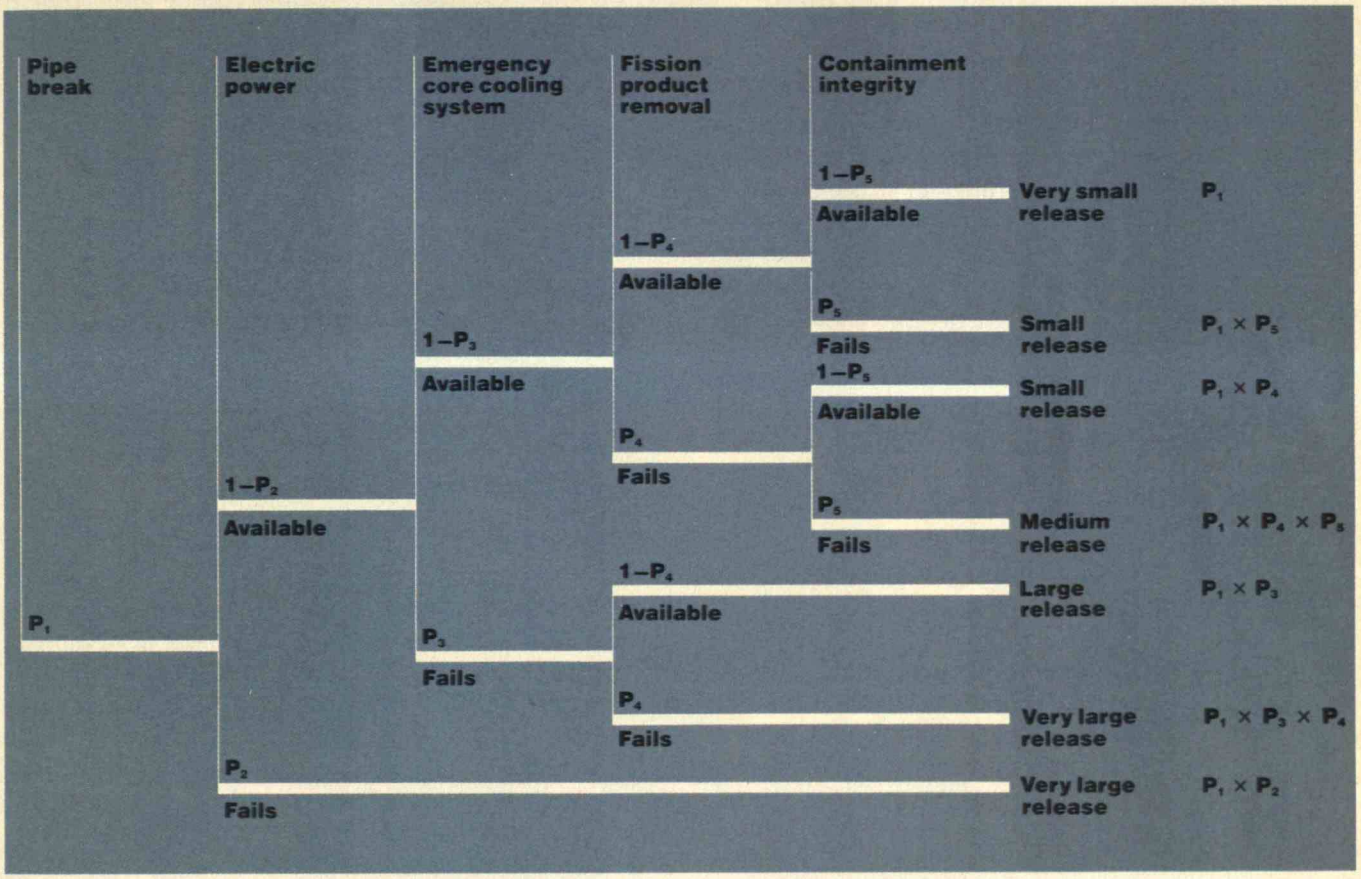
The actual quantitative results on the estimated public risks of nuclear power, while important, are perhaps the least useful results of PRA. Enough studies have been completed by now to tell us that the estimated risks from nuclear reactor accidents are quite small.

Engineering insights are the most important benefits of PRA studies. The most general of these is the entirely new way of thinking about reactor safety in a logic structure that transcends normal design and regulatory processes. PRA thinking introduces much-needed realism into safety evaluations. Deterministic thinking, in contrast, although it has served society well, often masks important matters.

PRA concepts can help improve understanding in many applications across a broad spectrum of activities, including engineering, licensing, and operations. The following are among its most important general insights:

☐ Contrary to what was previously thought, core meltdowns would not necessarily be catastrophic in

Engineers preparing probabilistic risk assessments for nuclear reactors rely partly on event trees. These indicate the consequences of specific accidents — here, a break in a pipe that might lead to release of radioactivity. Analysts assign probabilities (P_1, P_2, etc.) to each possible event in the sequence. Then, having satisfied themselves that all the probabilities in a sequence are independent of each other, they multiply them to obtain the overall chance that that particular sequence will occur.



terms of public risk. In fact, PRAs show that if a core meltdown occurs, there is only a small chance that the containment building will also fail in such a way that a large amount of radioactivity will be released.

☐ The notorious "China syndrome," in which the fuel melts through the containment basemat beneath the reactor, does not pose a significant risk to the public. Not only is this scenario unlikely; an analysis shows that, even if it happened, most of the dangerous materials would be retained in the concrete and the soil. Releases of radioactive materials from this event would be very much smaller than if the building itself had been ruptured.

☐ Current reactor designs provide great capability to reduce the consequences of potential accidents that are more severe than those considered in the licensing process.

☐ The most significant accident sequences in pressurized-water reactors in common use in the United States do not result from large pipe ruptures, as previously assumed. Breaks in large coolant pipes are unlikely, and reactors have been specifically designed to cope with them. The overall risk of accidents that result from ruptures in small pipes and subsequent failures of safety systems turns out to be greater.

☐ "Transient events," when the power output of the reactor is being changed, also pose potentially significant risks when combined with additional failures in safety systems.

☐ The most significant accident sequences in boiling-water reactors do not involve loss of coolant, but stem rather from transient events.

☐ The importance of strong containment buildings and reliable safety features, such as the emergency coolant-injection and heat-removal systems, has been highlighted and quantified.

☐ In general, human factors—errors in testing, maintaining, and controlling plants—account for a significant, but not dominant, part of the public risk that might arise from reactor accidents.

DIAGRAM: OMNIGRAPHICS

Industry can use PRA in many ways, from designing plants to managing them.

A Tool for Regulators

Existing NRC regulations and other requirements were developed without the benefit of the engineering insights made possible by PRA. It is clear that regulatory requirements and processes would be made more consistent and rational if they were to be examined from a PRA viewpoint.

One positive sign of PRA's value to regulation was its official acceptance by the NRC. In a memorandum establishing the Committee to Review Generic Requirements in October 1981, NRC Chairman Nunzio Palladino stated that the analytical tools to be used "would be expected to include cost-benefit analysis and probabilistic risk assessment where data for its proper use are adequate." The establishment of the committee, with PRA and cost-benefit analyses in its charter, has helped to focus new regulatory requirements on issues that are genuinely important to public risk.

In addition, the NRC is now planning an Integrated Safety Assessment Program (ISAP). This is intended to replace the Systematic Evaluation Program, which evaluated older plants against present regulations, and the National Reliability Evaluation Program, which was to have carried out PRA studies for all plants. After completing a pilot program on a few reactors, ISAP will probably require that PRAs be done on all U.S. commercial reactors, at the rate of about six per year. Utilities will use the results, along with other available information on safety, to address all outstanding regulatory issues that affect their plants. The utilities will be expected to recommend which issues need to be considered, which not, and why, and to suggest programs to carry out needed changes.

This approach is to be commended, because it represents a good attempt to combine in a sensible way the insights from the normal regulatory procedures with those from PRAs. As the NRC reviews and approves the plans of individual utilities, it will establish a body of practices that it can later use to treat outstanding issues in a generic way, rather than case-by-case.

A few words are necessary on where regulators should not use PRA. The routine use of complete PRAs as part of the licensing process for individual reactors is of questionable value. This is because the focus of reactor licensing is on compliance with regulations—and the regulations do not address risk quantitatively. However, PRA techniques can be used to help settle individual issues in the licensing process. Thus, PRA should not be used to replace the existing licensing process, but rather as a supplement to it where appropriate.

A Tool for Industry

Industry can use PRA in many ways, from designing plants to managing them. So far, the U.S. nuclear industry has barely begun to reap the possible benefits of PRA. Instead, the industry has used the technique mainly to resolve immediate problems—usually to respond to questions or directives from the NRC. For example, the NRC was concerned about the high population density near the Indian Point plant in New York. As a result, the plant's owners did a PRA to help decide whether additional safety systems were needed, and, if so, which would be most appropriate.

The Consumers Power Co. is using PRA in a more comprehensive way at its Big Rock Point plant in Michigan. About half a dozen people, familiar with the overall logic and details of the PRA performed for this plant, are carrying out a Continuing Risk Management Program. They update the PRA to reflect safety improvements in the plant, new maintenance procedures, and possible deteriorations of components as they age. Thus, the PRA gives a continually changing picture of risk estimates for the plant. The plant owners use this picture to get a better feel for where they can best spend money for improvements, and to evaluate safety issues as they arise. Commonwealth Edison in Chicago and the Tennessee Valley Authority in Knoxville are also using PRA extensively.

PRA provides a whole new way of thinking about reactor safety for people in industry and government alike. Used with imagination, it can help refine the fabric of existing regulations, to make them consistent and rational; improve the operation of existing reactors and the design of future ones; reduce wasted effort on issues that are not important to safety; estimate the degree of compliance with safety goals; and provide a better understanding of safety issues that arise from the use of nuclear power.

SAUL LEVINE is vice-president and group executive for the consulting group NUS Corp., in Gaithersburg, Md. His 30 years of experience in nuclear energy include 17 years with the Atomic Energy Commission and the Nuclear Regulatory Commission.

MIT

FEBRUARY MARCH 1984

The "Pac-Thing" Winner

see page A2

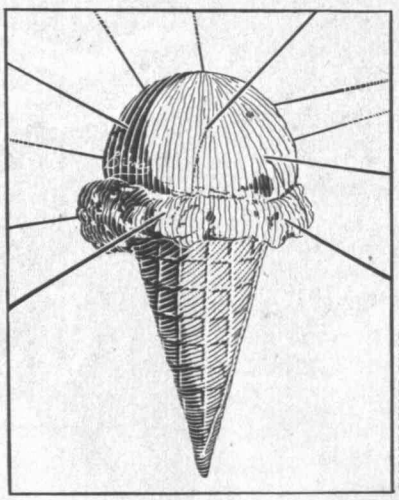
COMPLETE CONTENTS FOR THIS SECTION ON PAGE A2

The Soul of a New Ice Cream Machine

Student View/Diana ben-Aaron

"Even these metallic problems have their melodramatic side." —Oscar Wilde

When I began work in the Superconducting Materials Group at the beginning of the summer in 1982, I was given a stack of the group's publications and other background literature to read. Some discussed possible applications of superconducting materials, including a fusion magnet and a train floating on an electric force field produced by superconductors. Some discussed the group's research methods and results, and some described the group's avowed purpose—to come up with fast, cheap heat treatments that industry could easily carry out to make simple copper - niobium wires into powerful superconducting wires. The deadly prose style of the technical paper did not conceal a sense of glowing enthusiasm for this effort and its goal.



CHRISTOPHER BING

Life With a Copper-Tin Phase Diagram

The wires we used were not superconducting to begin with. Each consisted of dozens to thousands of niobium filaments embedded in a thicker copper wire, the whole perhaps one-hundredth of an inch in diameter. The first step in each experiment was to clean the wires, originally a complicated task involving acetone on a paper tissue, a vapor degreasing appartus, and an acidic "pickling" solution that removed the outer layer of metal and oxide.

Then we electroplated each wire with tin and heated it in a furnace. At several hundred degrees Celsius the tin diffused into the wires, making the niobium into a niobium-tin superconductor, and the copper became bronze (copper plus tin). Since the particular type of bronze surrounding the superconductor could influence its properties, our research focused on charting the ratios of copper to tin in the bronze and preventing the bubble-like voids (Kirkendall porosity) that were apt to form during the diffusion process and ruin the wires.

The day-to-day *modus operandi* of the group was based on the copper-tin phase diagram, a "map" of the different varieties of bronze and the temperatures and copper-tin ratios that produced them. The copper-tin phase diagram and an accompanying manual for interpreting phase diagrams (referred to as "the book of all knowledge") were consulted at every turn:

- ☐ What should we do today? Let's take a look at the copper-tin phase diagram; maybe that'll give us a clue.
- ☐ What do these results mean? The first thing to do is compare them to the copper-tin phase diagram.
- ☐ Where shall we have lunch? Better see if the copper-tin phase diagram has anything to say about it.

"It would be understandable for them to have tired of laboring on a project whose fruits they probably would not live to see."

The Shine Comes Slowly Off the Apple

The more complex procedures, such as the almost-surgical sterilization routine

Continued on page A25

MIT

FEBRUARY/MARCH 1984

In This Issue

Letters

When To Choose Where to Live?

I was saddened to learn that the pre-freshman fraternity and dormitory rush system still exists at M.I.T. (*see "Initiation to M.I.T. for a Gregarious New Class" by Peter Mui, '82, November/December, 1983, pp. A4-A12*). I remember well that my first week as a freshman at M.I.T. in 1967, which should have been thrilling, was ruined by having to worry about where I would be living that year. After a summer of the fraternity "hype" in pamphlets in the mail, I joined a fraternity. I am not sure that I would have made the same decision had "rush" occurred six months later. I also remember a number of friends who, like the freshman mentioned in the article, had visited too many houses and so ended up in a dorm—and thus began M.I.T. feeling rejected.

I am sorry to see that a system which creates anxiety, disappointment, and regrets has been allowed to continue.

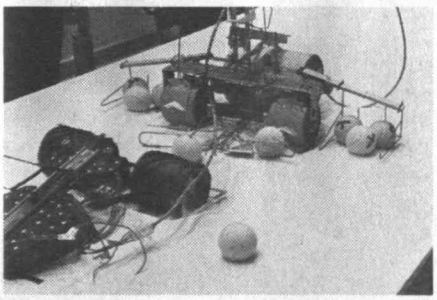
Ira J. Goldberg, '71
New York, N.Y., 10032

On the Cover:

Winning with a Joystick-Controlled "Pacthing"

Use this kit of "stuff" (**above**) to build a remotely-controlled machine to move tennis balls from your end of a sand table to your opponents' end—before the enemy's device can move more balls to your end of the table.

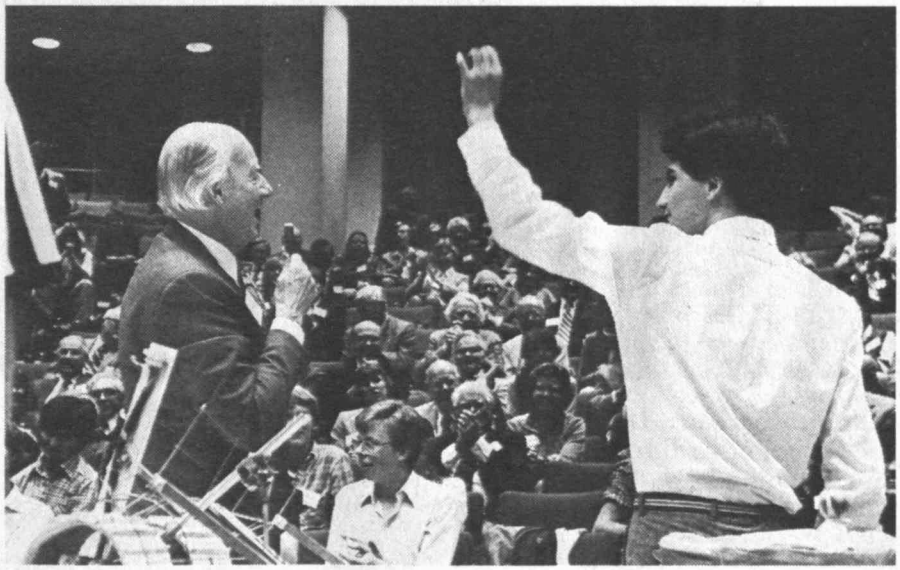
That was the challenge in this year's version of the famous "2.70 design contest."



Included in the kit of parts: a couple of small electric motors to be controlled through an umbilical cord connected to a "joystick," an assortment of tubes, gears, belts, and cables, and a "joystick" wiring plan.

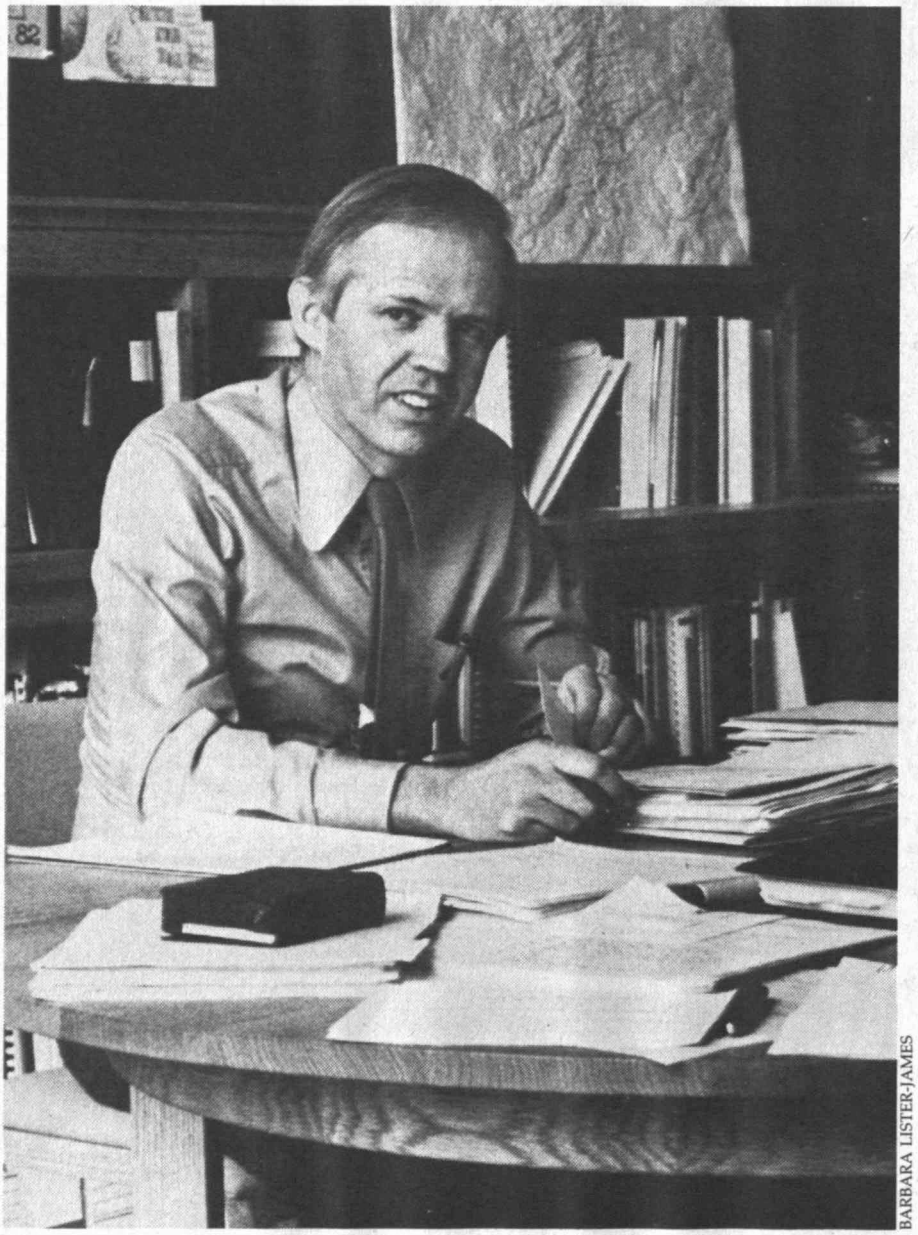
Alex P. Praszker, '85 (**above**), was posed with the parts, but the eventual winner was Mark J. Schlueter, '85 (**cover**).

Schlueter's success depended as much on designing strategy as designing a machine. Schlueter's winning "pacthing" began by ejecting a barrier intended to immobilize the opponent's machine, leaving the field of tennis balls on two-inch-deep sand a push-over. A similar strategy (**left**) proved successful for Glenn S. Weinreb, '86, in a rerun of this year's contest for the Alumni Council (**below**), when Schlueter's device misfired.



The Mark of M.I.T. Architects: Vigor, Integrity, a Style All Their Own

They Claim More Than Their Share of Scarce Jobs



BARBARA LISTER-JAMES

John deMonchaux, Dean of the School of Architecture and Planning

Two years after he arrived from Australia to become their dean, Professor John de Monchaux says that M.I.T. architecture and planning students have "a vigor and an energy about them that is enormously stimulating.

"I expected them to be this way, and they are," he told *Technology Review* late last year.

One result is "an approach to the design of buildings and environments that is distinctively M.I.T.," Dean de Monchaux says—a kind of pragmatic honesty. Hard to describe, Dean de Monchaux admits, but he thinks this special quality really derives from two qualities:

☐ A concern for the "immediate human environment"—how whatever is built will affect what was there before and whatever follows—especially the quality of people's lives.

☐ An insistence on integrity, so that all elements of a built environment reveal themselves for what they are—no disguises.

Singular Integrity

These qualities seem to Dean de Monchaux to yield designs and plans that are closer to work by students in European architectural schools than such places as Harvard, Princeton, Columbia, or Yale. The result is that many of the buildings that Institute graduates of the last five to ten years are designing today can be recognized as M.I.T.

An important influence, Dean de Monchaux says, is the Ph.D. pro-

gram in history, theory, and criticism—a group of students focussing on theories of architectural form. Another is the master of science in architecture studies program, which is a research degree for already-qualified professionals.

M.I.T. undertakes more research in architecture than any other department in the country, says Dean de Monchaux. Even so, the research volume is very small compared to that in, for example, the engineering departments at the Institute, for architects are not, as a profession, accustomed to inquiring into the uses and applications of architecture. M.I.T. research focuses on energy consumption and conservation—the relationship of design, construction, and materials to such qualities of space as lighting and energy efficiency. There's also work on behavior and architecture—the human components of design.

Exposing the Substance

The buildings that are designed by students who have learned in this environment may show more complexity than the deceptively simple designs of much modern architecture. Every detail has its purpose and every purpose its detail. The role of each element is clear; the architect's intentions are fully revealed.

This same integrity, says Dean de Monchaux, also characterizes the school's work in planning—concern for the well-being of every affected

Ann Beha Associates
Boston, Mass.

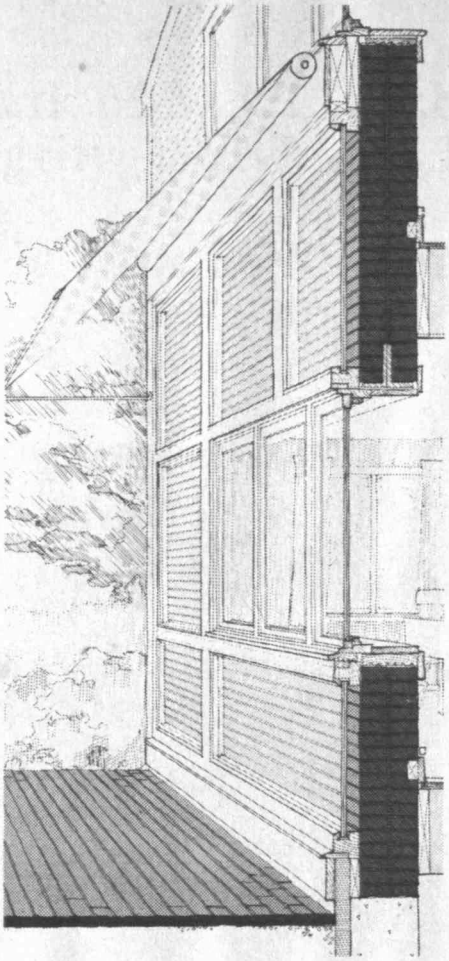
Restoration of the Arlington Trust Co. building, Lawrence, Mass. Before (left) and after (below)

Project team: **Ann Beha,** M.Arch.'75 and **Marilyn Brockman,** M.Arch.'79

1982 Preservation Award of the Massachusetts Historical Commission

JAMES HIGGINS

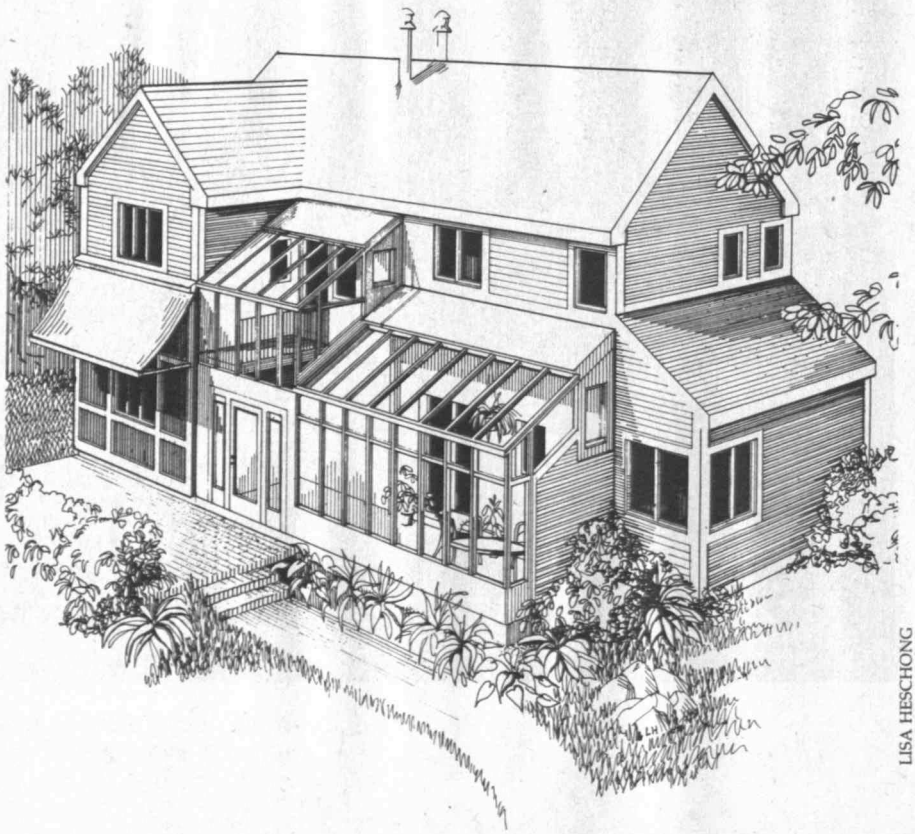
. . . a pragmatic honesty in the design of buildings and environments that is distinctively M.I.T.



Total Environmental Action, Inc.
Harrisville, N.H.
Bruce Anderson, M.Arch.'73,
president

The Brookhaven House
Design for Brookhaven National Laboratory
Project Manager: Ralph F. Jones

Right: detail of modified Trombe wall with triple-glazed panels mounted outside of paving-brick wall to trap solar heat.



LISA HESCHONG

individual, a basic honesty that precludes the victory of special interest over social need.

The school's research activity is also spawning what Dean de Monchaux thinks is some of the best current thinking in the U.S. about the theories of architecture—how buildings and rooms should respond to the psychological needs of those who will use them, how the spaces they inhabit can help people release their skills.

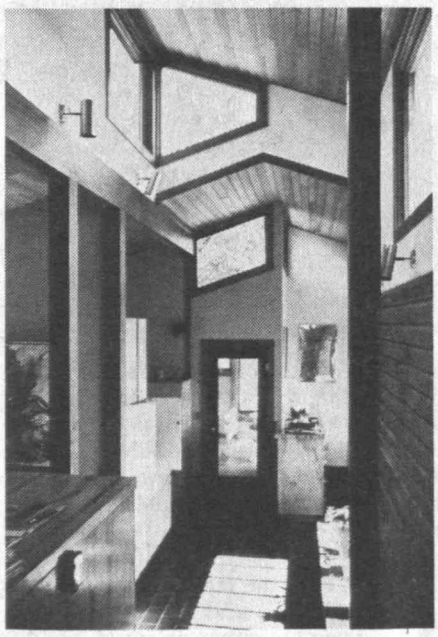
Getting More Than Their Share

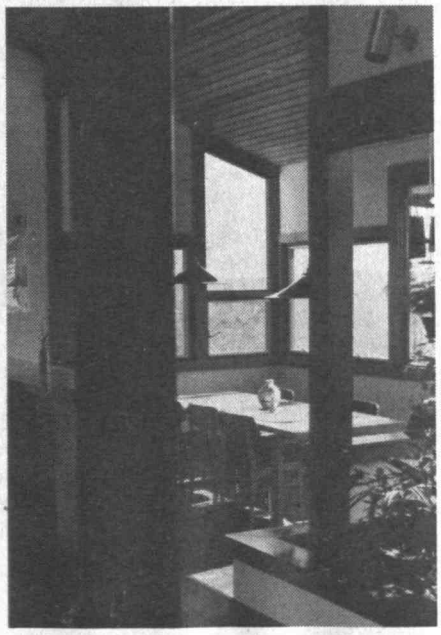
A school with these strengths is not without its problems, however—and most of them revolve around money, Dean de Monchaux says. For architecture students the cost of education is high, the return after graduation likely to be low. That ratio—the cost of going to school compared to earnings upon graduation—is "very, very poor.

"Our students on graduation as architects earn typically $15,000 to $17,000 a year. Yet a student who has spent three and one half years doing a graduate course in architecture could leave the Institute with a debt of $40,000 to $50,000, and the repayment is a very heavy burden." For planning students it's only a little better: on average they study for two years rather than three, and their starting salaries are a little higher (about $18,000 to $20,000).

So new sources of money to help students and lessen their need to borrow has the highest priority in the school's fund-raising efforts. "Good students have turned us down explicitly because of the expense," Dean de Monchaux says.

On employment: "Jobs are scarce, but I think our graduates get more than their share. A straw poll established on graduation day that there were only a couple of students that weren't yet placed."





PHOTOS: MICHAEL UNDERHILL

Michael J. Underhill, B.Arch.'70
Department of Architecture,
Rice University, Houston, Texas

Alfred Susskind House
Southborough, Mass.

Interiors: kitchen (left) and dining areas.

No Limits on EECS Enrollment: The Faculty Fails to Grant Overload Relief

Between a Rock and a Hard Place on "The Problem"

Electrical engineering has traditionally been the largest M.I.T. department, but it's growing at a rate that has everyone breathless. More and more undergraduates seem to see computers, microelectronics, and communications as the wave of the future.

In 1982 340 sophomores designated Course VI as their major. This year, 380. Next year, well over 400 by present indications.

The department's total undergraduate registration for 1983-84 is just under 1,200.

That number—about 25 percent of all M.I.T. undergraduates and more than half of those in engineering—represents "a crushing burden in terms of the need to teach, to advise, to supervise thesis work," President Paul E. Gray, '54, told Diana ben-Aaron in a *The Tech* interview late in the fall. . . . "a whole set of problems relating to the number of people, the size of classrooms, the size and capacity of laboratories, the number of faculty. . . . Something needs to be done to bring the number of majors in Course VI under control at a level which will not do serious damage to the department."

Can't M.I.T. simply expand the EECS faculty? asked ben-Aaron. Not so simple, explained President Gray. It's partly a question of space—offices, laboratories, and classrooms. It's also a question of money (Gerald L. Wilson, '61, dean of engineering, sets the need at 30 faculty and the cost at $1.8 million.) But most of all it's a question of people. "There just aren't that many people at the level of qualification that is needed," President Gray told ben-Aaron.

The issue gradually grew to major importance during the fall—people began to identify it simply as "the problem." Professor Bruce R. Musicus found that he had 80 students registered for 6.115—microcomputer project labortory; 40 had to be turned away for lack of equipment and space—try again next term, Musicus told them. 6.170—the sophomore software engineering laboratory course—was closed to sophomores so that all the upperclassmen could be accommodated (they had fewer options for taking it later).

Two Kinds of Students—the "Cans" and "Can'ts"

After weeks of deliberation, the Committee on Educational Policy found itself with a clear need to act but no easy answers. It finally presented two alternatives for 1985-86, the first year when any change seems possible, at a special faculty meeting in December:

☐ Ask freshmen who want to major in electrical engineering and computer science to apply, in writing, and take a test that focuses on basic understandings in mathematics and physics relevant for EECS work. The department would select the best-qualified applicants up to the limit it could accommodate; other applicants would simply have to choose different majors.

☐ Ask applicants to M.I.T. for the Class of 1988 to say on their applications whether or not they want to study EECS. Those that say "yes" go in one pool, those that say "no" in another. The regular admissions process proceeds with each pool, with the number of EECS "yes" applicants being limited to the number that department could handle. Other qualified applicants are given admission to M.I.T. without the privilege of an EECS major.

It was a tough choice, said the CEP—"a difficult decision between severe ongoing damage to an outstanding department and an action which restricts a freedom of choice that is valued by both students and faculty," said Arthur C. Smith, chairman of the faculty. But he also urged the need for action: "The CEP is recommending strongly that the faculty . . . allow us to control the number of Course VI majors in the Class of 1988."

Extra

The Tech

Faculty rejects CEP proposals

Opts for no action on overcrowding; opposes restricting EECS enrollment

Analysis

EECS faces troubled future

Though *The Tech* endorsed the faculty plan to limit enrollment in electrical engineering and computer science, its editors shared the perception of "a very bad precedent"—and reported the faculty's standing-room-only meeting in an outstandingly good extra edition.

In the end, the faculty—finding itself between a rock and a hard place—refused to accept either proposal. So "the problem" went back to the CEP for a long-range solution and was handed to the department for 1984-85 and 1985-86. Bad news, said Dean Wilson. Pressed to the wall, Course VI will probably have to limit enrollment in more of its courses, may well give its faculty less time for research and writing, and may have to end the undergraduate thesis.

How to Broaden Our Views of the World

Actress Zoe Caldwell Is Surprised by "Civilized Awareness" at M.I.T.

By China Altman

The Council on the Arts may have expected an address, but what came from actress Zoe Caldwell was an ode to M.I.T.—showing "the rest of the world" that science and the arts can "stay on the same side. . . . If we can do that, I just feel we can be so potent as to . . . stop a nuclear war," she said.

When actress Zoe Caldwell was introduced as McDermott Award speaker at the annual meeting of the Council for the Arts late last year, she swept dramatically onto the stage and instantly had her audience in hand with a remarkable multi-layered solo performance that wove together her passion for connecting human beings to each other with some insightful impressions of M.I.T.

When she finished, the Council members found themselves overwhelmed—then suddenly rose to give Caldwell a standing ovation. Jerome B. Wiesner, chairman of the Council on the Arts, said she converted what he thought would be a speech "into a happening—a great performance."

Ms. Caldwell enthused about the day she spent on the M.I.T. campus before her appearance, mentioning especially the beauty she saw in a fluid dynamics laboratory and how she had been "deeply moved by the level of awareness among the teachers of science and technology" whom she met.

"I had expected that M.I.T. would be a place of harsh, technical sensibilities," she said. "And what I was introduced to was a very civilized awareness, a marvelous sensibility about human beings and an awareness that we must keep the two lots of sensibilities in balance."

Beauty itself is where science and technology connect with creative arts, she said. She appealed for the two disciplines "to stay on the same side.

"If we could do that," she said, "I just feel we could be so potent as to almost stop a nuclear war. The thrilling part is that you at M.I.T. are showing the rest of the world that it can be done. I am so grateful to you."

Professor Wiesner, speaking briefly after Caldwell's presentation, said, "Your observations have demonstrated what it is we are trying to do to make sure that technology and human purpose are connected and that they stay connected to make a better world."

Before her address, A.R. (Pete) Gurney, Jr., professor of literature, was presented with the McDermott Award, given annually "to an individual in the M.I.T. community for major contributions to the arts as a means of human fulfillment."

Power to Link Arts and Technology

In his address to the Council's luncheon meeting, President Paul E. Gray, '54, had a strong defense of the arts in undergraduate education at M.I.T.:

"While it is true that scientific education demands specialization, we must guard against the pressures which narrow students' views of the world. Indeed, I believe that significant contributions to science and technology will come more often from men and women who are broadly cultured than from those narrowly specialized. . . .

". . . We must ensure that our students have the humanistic dimension to appreciate a wide range of values in order to become responsible decision makers and creative problem solvers in the modern world," President Gray said.

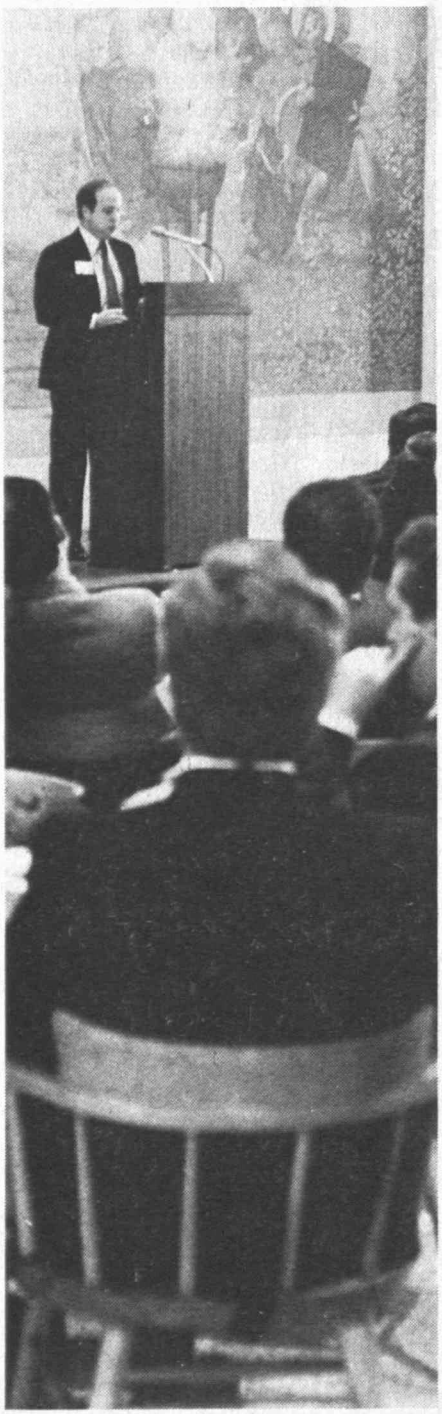
China Altman is a well-known Boston journalist who covers the visual and performing arts for the M.I.T. News Office.

PHOTOS: FRANK REVI, '86

Genentech, the most successful genetic technology firm, "went public" in 1980 when it needed more capital than it could find in the private market, and because it was ready to put its success on the line. The confidence was not misplaced; Genentech stock has never been below its offering price, Robert A. Swanson, '69, told an envious audience of venture capitalists and would-be entrepreneurs at the annual Enterprise Forum workshop last fall.

The Forum Turns to Buying and Selling

But Like Used Cars, the Best Companies Aren't For Sale



Five years ago you took the plunge—went into business for yourself, starting a company to exploit your very own high-technology innovation.

Now your successful entrepreneurship has brought you to another crossroads. Business is good, expanding rapidly—almost too good. You need more people, more capital. . . .

. . . Or maybe you need to get out, slow down a little after five years of hard work, reap some rewards, develop that other innovation you set aside two years ago.

Sell the business? Take a partner who has the capital and will share the load? Go public?

Be careful: buying and selling a high-technology company is a little like buying and selling a second-hand car, according to speakers at the M.I.T. Enterprise Forum's 1983 Entreprenurial Workshop:

□ Not every high-technology company is a booming success, and the owners of those that aren't may well put them on the market at bargain prices—just like "lemon" used cars. Buyer beware, warned Stanley R. Rich, executive vice-president and technical director of Advanced Energy Dynamics, Inc., who is chairman of the Enterprise Forum.

□ Another reason for selling of which buyers should beware, said Rich: the company is doing fine now, but the lifetime of its principal product is running out. Like the cream-puff used car in which the rust hasn't quite yet surfaced.

□ Buyers do better if their newly-acquired companies are in familiar fields, said Edward B. Roberts, '57, Sarnoff Professor in the Sloan School. It's a matter of familiarity—just as a Cadillac owner is likely to be happier with another Cadillac than with a Civic.

□ And the Civic may not work so well for the Cadillac owner: there is likely to be a mismatch leading to frustration among its employees when a small firm is acquired by a big one. From the perspective of the small firm's employees, the time required for decisionmaking suddenly becomes longer, communication with top management is suddenly harder and probably more formal.

The most successful companies seem to be those that concentrate their work in a few fields in which they become expert.

For the President: Carpeted Back Office

The 1983 Enterprise Forum workshop, on "Buying and Selling Technology-Based Companies" at M.I.T. on October 28, was the largest in the six-year history of the day-long program; the venture-capital-related business of buying and selling high-technology companies is flourishing. It's a multidimensional business: workers, buyers, investors, catalyzers, sellers, tax collectors—all have interests to be served by successful transactions, and so transactions become technically complex. Topics such as valuation, the alternatives to selling (taking on partners or going public), the roles of consultants, how to prepare a company for a change of ownership, what to do to assure employees of continuity and to assure a buyer that the expertise of the employees will be acquired . . . all these are well worth a day's discussion. Even, during the cocktail hour, what to do with the president of the company you've just bought. Answer: give him a well-carpeted back office for year, and then let him go.

Professor Roberts' observations (above) come from a recently-completed study of large companies that have sought to enter new markets by acquiring companies already in them. It's a tricky business, according to Roberts' results—probably a poor reason for buying.

Genentech: Investing in People

The day started with a pessimistic report from Peter G. Peterson, former secretary

It happens in public every month in Cambridge—a panel of experts (foreground) convened to hear and comment on the innermost secrets of a new, high-technology enterprise. On the stand when this picture was made were Peter Kramer, '70 (left), and Frank Manning, '70, chairman and president, respectively, of Zoom Telephonics, Inc. At the right: Vincent A. Fulmer, S.M.'53, secretary of the M.I.T. Corporation who was chairman for the evening.

Enterprise Forum Critics Are Unawed by Success

"Silencer" . . . "Demon Dialer" . . . "Hot Shot" . . . if the products are as good as their names . . .

And they evidently are, for net sales of Zoom Telephonics, Inc., have gone from $746,000 in 1981-82 to $3.9 million in 1982-83—and an estimated $10 million in 1983-84, $25 million in 1984-85. Return on capital was 78 percent in 1982-83, return on sales 10.5 percent.

With this kind of record, Zoom Telephonics sounds like a company without problems, just opportunities. Why, then, did its founders, Frank Manning, '70, president, and Peter Kramer, '70, chairman of the board, seek a hearing before an expert panel of the M.I.T. Enterprise Forum?

Because they want the future to be as rosy as the present, because they think Zoom is undercapitalized in terms of its future opportunties, and because everything that Manning (an electrical engineer) and Kramer (a physicist) know about management has been learned on the job. They worry at once about growing too large too fast and about having too little money to market the new products they're researching. Borrow money? they asked the Enterprise Forum. Or "go public" to raise equity financing?

Public Dissection—Nothing Barred

There's nothing unusual about these questions that Manning and Kramer brought to the M.I.T. Enterprise Forum. Once a month two companies—Zoom is typical—put their management problems in front of panels of experts recruited by the Forum. On one condition: everything is in the open—nothing hidden from the panel or the audience that averages at least 250 for every case presentation.

The Enterprise Forum in Cambridge is an offspring of a New-York-based M.I.T. Venture Clinic. Now the idea has spread to Washington, Chicago, and the West Coast—but with a difference. The West Coast people "don't want to be put on a stand and destroyed," says one observer. In contrast, he says, "the Yankees don't seem to mind having their dirty linen washed in public."

Making Telecommunications Faster

Not much dirty linen was aired when Zoom went before the Enterprise Forum critics in Cambridge late last year. The company's growth is solidly built on three products.

"Silencer" keeps your telephone from ringing for a preset period and takes messages from those who call. It was Zoom's first product, a low-risk, low-cost item that at least in retrospect had one big advantage to Manning and Kramer: It gave them a chance "to debug the business at low cost," they say.

Then came their first "hot" item, "Demon Dialer." It stores over 150 of its owner's most-called telephone numbers, dials automatically, and redials busy and unanswered phones until told

Continued on page A26

Entrepreneurs who want to have their companies subjected to an Enterprise Forum panel's scrutiny should call the Forum's executive director, Paul E. Johnson, Room 10-110, M.I.T., (617)253-8240. Activities are announced in the Forum Reporter, *to which subscriptions are available from Johnson.*

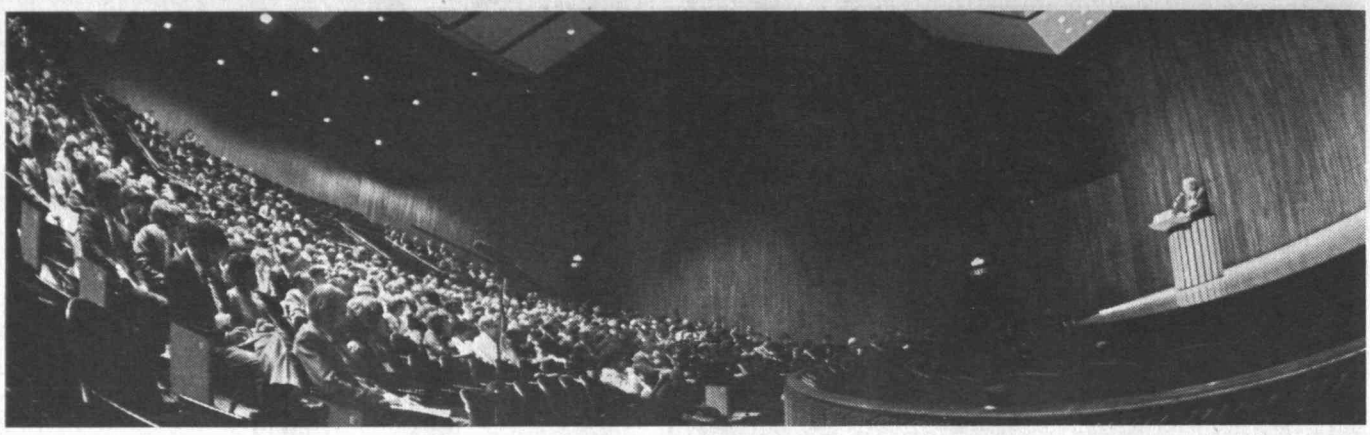
---

of commerce who is now chairman of Lehman Brothers Kuhn Loeb, Inc.: current U.S. deficits are "huge, destructive . . . a cancer on the U.S. economy that threatens to metastasize to bring disaster to the world economy as well." The private sector, said Peterson, used to claim for investment at least 70 percent of U.S. savings, but now the government is taking an increasing share, soon perhaps up to 50 percent, and there may not be enough to underwrite all the new technology looking for investors.

Frederick Frank, the managing director of Peterson's firm, offered a shorter-range forecast that was only slightly less gloomy. The shortage of venture capital that crippled many entrepreneurs in the 1970s is likely to return later in the 1980s, he said. Today's markets, with capital generally available "in reasonable quantities and at reasonable prices," may not last much longer.

But the enthusiasm of the card-trading entrepreneurs at the workshop seemed undampened by this threat to the funds they need for investment. They liked better the message from Robert A. Swanson, '69, president of high-flying Genentech, Inc. The company is not for sale (general laughter) and the original management really doesn't know what share of total equity it retains (general surprise). "You can waste a lot of time worrying about keeping control," Swanson explained.

How did Genentech do it? Good ideas, of course, but mostly good people and good discipline, Swanson said. "Enormous energy" is required to bring a new product into the pharmaceutical market, and Genentech has concentrated fully on exploiting a few new products, deliberately building slowly to make a strong company for the long run. Swanson gives most of the credit to Genentech's employees ("our investments in people are what has made the difference," he told the forum audience) and to the policy of "making sure that the employees share the company's success and enjoy coming to work every day." Every Genentech employee has a chance to be a shareholder, and most are.



David Rockefeller, Chairman of Chase Manhattan Bank: "Nothing could be more conducive to stagnation and self-satisfaction than protectionism."

A Brief for Free Trade

The Sloans Return to Preserve Their Image as Contentious, Disrespectful Brats

Competition is competition—whether it comes from Japan, darkest Africa, or across the street. And the way to beat it is the same, no matter where it comes from: better goods, lower costs, better marketing.

To seek protection from a competitor is admit a fatal weakness—the beginning of the end.

But having heard this message with a good deal of passion from everyone on the rostrum for nearly a whole day at M.I.T. this fall, one former Sloan Fellow, back for renewal with his former teachers and reunion with his colleagues, finally grew impatient. "I come from an industry that depends on international markets for half of its labor," he told Professor Paul Samuelson's afternoon panel. "I want *fair* trade, not *free* trade!"

It is as Professor Barbara Westney was warned by a colleague as she was preparing for her first-ever class of Sloan Fellows last fall: "They're the best group to teach—you learn so much. And they're the hardest group to teach—they know so much." Or as Professor Daniel Holland complained after a seminar during the 1983 Sloan convocation in October: "They've never had any respect for the academic position. They expect facts and opinions that we're in no position to give."

Our problem: the "Swiss disease," J. Harry Goldie, S.M.'65, told his colleagues and the convocation's afternoon panel. Like the Swiss franc, the value of the dollar is too high, so our products—and those of the Swiss—are overpriced on world markets. Goldie's solution: higher taxes, lower interest.

Free Trade vs. World Tension

"Free-trade" advocates completely dominated the convocation on October 13-15, whose program theme was international economic competition. The Sloan Fellows' lessons in internationalism began even while their old mentor Howard W. Johnson, now honorary chairman of the Corporation, was greeting them. Tensions arising in increasingly intense international competition, especially in high-technology fields, carry the threat of "massive misunderstandings," Mr. Johnson said. The health of many economies in the 21st century is at stake, he thinks, and he cited the 1982 National Academy of Sciences study that he headed in calling for "new ways to deal with misunderstandings arising in economic competition."

To defuse that threat, keynoter David Rockefeller, chairman of Chase Manhattan Bank's International Advisory Committee, has three recommendations:

☐ A more global business orientation throughout the world. It's a "world economy," he said, with world trade climbing even faster than world population. But our institutions haven't changed, and for that reason we're "perpetuating a 'protectionism of ideas.' . . . Breaking down these walls of 'thinking as usual' is the most important challenge facing the U.S. today."

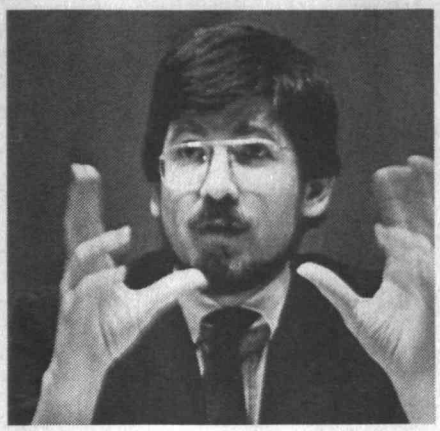
Continued on page A14

Sloan Mini-Convocation

Former Sloan Fellows on the West Coast will gather on June 8 in Los Angeles for a one-day program of faculty seminars. Plans are being completed by Don Henriksen, S.M.'68, vice-president—government relations at Atlantic-Richfield Corp., and the meeting will be at ARCO's corporate headquarters. Further details: Alan F. White, director of Executive Education Programs at the Sloan School, Room E52-126, M.I.T.

PHOTOGRAPHS BY BRADFORD HERZOG

Institute Professor Franco Modigliani **(management): A major reason for urging international economic thinking: the imperfections in the monetary markets that make foreign exchange rates so unpredictable. The monetary markets would work better—to everyone's advantage—with more cooperation among world monetary agencies.**



Professor Donald R. Lessard **(management): Think globally, and be flexible. There's no reason not to shift production facilities from country to country and sources of supply worldwide. And every reason to try to design goods that can be marketed in many different countries.**

Institute Professor Paul Samuelson **(economics): Free trade is like a rose garden, with flowers (mostly) and thorns (a few). The thorns are for the low-wage workers. The jobs and wages of unionized high-wage workers in manufacturing industries are relatively safe, protected by the sacrifices of non-union low-wage workers whose competition is in a less-developed country.**

A Bullish Report on the Sloan School

Last June master's-degree Sloan School graduates claimed jobs with a median salary of $37,300—the highest for M.B.A.s of any U.S. business school.

That may not be an ideal measure of greatness, but Abraham J. Siegal, dean of the Sloan School, offered it with confidence to the alumni of the Sloan Fellowship Program at their reunion (*see chart*) as evidence of the school's fine health.

Three goals three years ago when Siegel became dean:

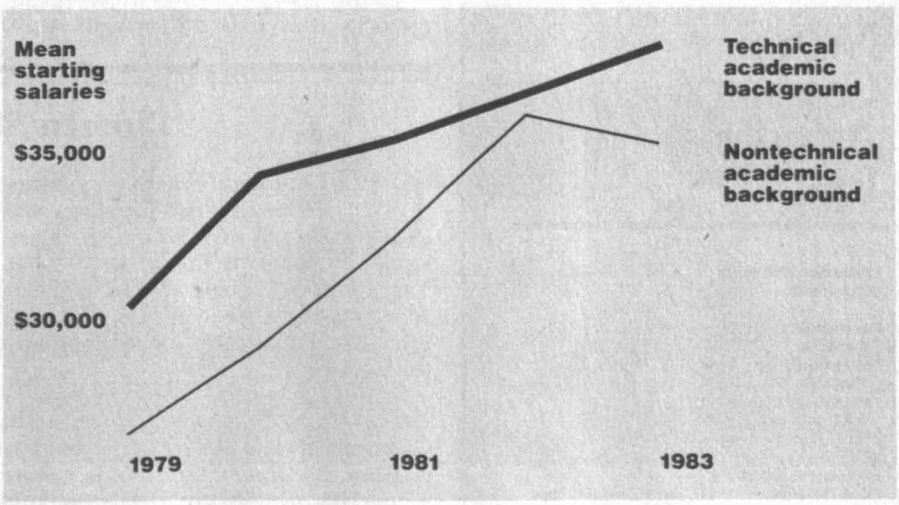
☐ Regroup the faculty to encourage better linkages among disciplines within the school—and in the rest of M.I.T. *Result*: now three areas of study—management sciences, economics and finance, and behavioral and policy sciences; faculty offices regrouped accordingly; increasing use of personal computers and other data processing machines with support from Citibank and IBM; new joint degree programs in the management of technology and (soon) manufacturing systems management.

☐ Sharpen teaching programs. *Result*: faculty salaries up—now comparable with those at comparable schools; outstanding new faculty recruited ("Clearly those outside the school are drawn to it," Siegal told the returning Sloan Fellows); faculty assignments regrouped.

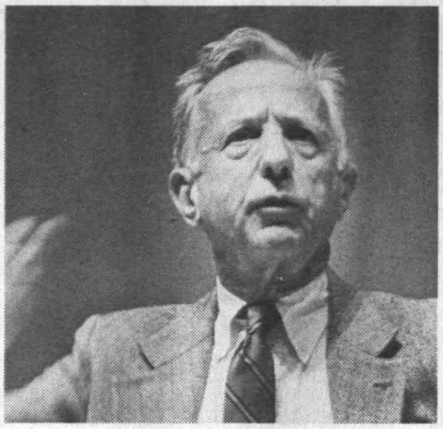
☐ Complete improvements and additions to plant. *Result*: new classrooms in Building E51, adjacent to the Sloan Building; complete refurbishing of the Sloan Building to be completed this winter; new Brooks Center at Endicott House to double the size of each 10-week Program for Senior Executives.

Only one major frustration, Siegal told the Sloan Fellows: we need a "quantum jump" in minority registration in the school.

Alan F. White, director of executive education programs, has some additional evidence for Siegal's proposition on the health of the school. This year's, he said, is the largest class of Sloan Fellows in history—a total of 57, with 9 women and 24 foreign students.



1983 starting salaries of Sloan School M.B.A.s were highest in the U.S. Figures in the chart show the power of the M.I.T. connection.



Professor Charles P. Kindleberger (economics): **The world political leadership of Britain after World War I and of the U.S. after World War II were the result of steadfast opposition to protectionism. Free world trade is a necessary economic stabilizer; it assures that there can be markets for distressed goods, shared resources for goods in great demand, steadier flow of capital.**

Professor Suzanne Berger (political science): **Embrace the new economic internationalism, don't fight it. You may think of tariffs and other protectionist measures as economic policy, but many countries see them as political—and respond with "aggressive anti-Americanism. Greater protectionism by the U.S. could catalyze a process of political disintegration that would be disastrous for us," she declared.**

A Brief for Free Trade

Continued from page A12

☐ Better understanding between public and private sectors. Though most of the world's economic activity is in the hands of the private sector, the major societal difficulties at the root of international tensions—hunger and poverty, for examples—are public-sector problems. Furthermore, public "pump-priming" is sometimes necessary for the success of private-sector initiatives. (On the other hand, Mr. Rockefeller warned of giving public-sponsored enterprises opportunities that the private sector could—and therefore should—fulfill.)

☐ Serious efforts to improve industrial competitiveness. Robots and other high-technology products are a superficial response to this need, said Mr. Rockefeller. They can't make much difference unless they're part of a larger general strategy to capitalize on strength and eliminate weakness. U.S. strengths are in technology, agriculture, and people, and Mr. Rockefeller's message was right down the Sloan Fellows' alley: "Too often interpersonal skills and the art of managing other people are given a back seat in our culture in favor of technical proficiency."

Women Stepping Out

U.S. women are now experiencing "the longest mid-life crisis ever known," says Edwin C. Nevis, senior lecturer in the Sloan School. That's because people are living longer; so the stages of life—youth, middle age, etc.—are longer, the bands between them wider.

But not to worry, Nevis told nearly 200 wives of Sloan Fellows at a Ritz Carlton breakfast during the Sloan convocation (*see above*). The trends toward longer life and better health in later years mean more opportunities, and the old constraints on women are melting away. It's now possible to say "hurrah!" when the last child leaves home—and much more possible than ever before to embark on a "second" career. Law schools, for example, are far more receptive to women than a decade ago.

And women bring to these opportunities a special advantage born of their deprivations of the past, thinks Nevis: the complexity and stressfulness of life in their youth and as young mothers has left today's women with flexibility and unusual power in what Nevis calls "contingent thinking."

Minorities Need Education, Identity, and Networks

A Reunion with an Important Difference

It looks quite a lot like a reunion—alumni returning to see classmates and campus.

But the annual Black Students' Conference on Science and Technology is a reunion with a difference: behind the busy chatter between students and alumni is the serious purpose of serious social change—increasing the numbers and influence of blacks in science and technology, and especially at M.I.T.

There are three imperatives to that change:

☐ Better education. "Our most fundamental need is basic education—reading, writing, and arithmetic," said President Percy A. Pierre, president of Prairie View A & M University.

☐ A strong force of cultural identity—the ability to be black in a white world. "If you lose sight of your cultural heritage," psychologist Gwendolyn Goldsby Grant, columnist for *Essence* Magazine, told her audience, "you will be educated against yourself."

☐ Better networking. Whites need of course to be more aggressive in their search for minorities for key technical jobs. But blacks need to be more visible in their availability.

Paul Parks, a major figure in the Boston black community, accused U.S. education of "self destruction" of blacks by "accepting mediocrity" in black-community schools. The quality of teachers is falling, and so is the education a student receives.

But there's a cultural problem, too. Schools and classes are built on the image of the typical American family—father, mother, and children. But half of U.S. black children come from single-parent families—no fathers. And "you cannot purvey education to half-families as you do to families," said Parks.

John B. Turner, associate dean of the M.I.T. Graduate School, agreed. He wants "a complete overhaul—a revolution—in the public schools," he said.

"Resistance to Reaching Out"

Do blacks have a reason to be hopeful? Parks was asked from the audience. Yes! he answered. We still may be pushing the familiar message—the need for more and better education. But there's been change and will be more, Parks said. "Our children are doing better today than yesterday, still better tomorrow."

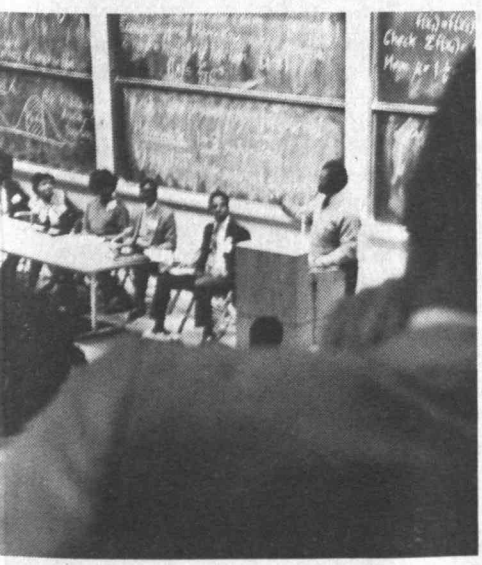
Will M.I.T. be ready for these better students, when they're ready for us? William McLaurin, director of the Office of Minority Education, isn't sure. "We need more action here, and less talk," he said. Blacks are now 1.5 percent of the M.I.T. faculty—16 out of 1,045, according to figures of Patricia Bell-Scott, the Institute's assistant equal employment officer. That's down from a peak of 23 in 1975, and Bell-Scott thinks "there is a general resistance within the Institute to being aggressive in reaching out for more minorities."

That's where the annual conference—and Black Alumni of M.I.T. (BAMIT), who help sponsor it—come in. Discussing the problem of recruiting minorities, Provost Francis Low told *The Tech* just before the conference that "there are indeed networks . . . used to aid the process [of recruiting new faculty members]." Blacks should be part of those networks—or be stronger in developing their own. And Bell-Scott added emphasis on "the need for departments to be aggressive in searching for minorities . . . particularly in forming ties with minority networks.

"Not making these contacts," she told Kevin D. Hurst, "results in leaving the search without uncovering some well qualified blacks that are out there."

Thus networking shows up high on BAMIT's agenda. Members spoke at two business meetings during the 1983 conference of the need for a directory and for enhanced regional programs as well as higher participation in next year's national conference. They'll seek a 20-percent increase in BAMIT membership by next fall.

A conference frustration that may be a serious constraint on meeting some of bamit's goals: too few undergraduates were on hand. They did not learn of the interest and support for their careers to which BAMIT is committed, and they missed an extraordinarily moving statement from columnist Grant: You who are students at M.I.T. "have a date with destiny. Education is a source of power. Make it your—and our—hope, blessing, and treasure!"



Highlights of the annual black students' conference: Nelson Armstrong and a panel of undergraduates meeting with prospective students (left); James M. Turner, Jr., Ph.D. '71, receives a BAMIT Award (center); and Austin V. Harton, '78, reports on his laser research at M.I.T.

Real Estate Development Goes Academic

An End to Learning by Accident

Real estate developers play a crucial role in shaping modern environments—housing, industries, whole cities. But—unlike the architects, civil engineers, financial people, and planners with whom they work—developers' skills have never been fostered in colleges and universities.

"Universities teach the skills and professions that provide for other necessities of life," says Charles H. Spaulding, '51, former chairman and president of Spaulding and Slye Corp., Boston. "But somehow the building development process has been neglected."

No more.

For in retirement from his Spaulding and Slye job "Hank" Spaulding has moved across the river to M.I.T., where he's directing a new Center for Real Estate Development in the School of Architecture and Planning. Next year the center expects to enroll as many as 25 students in the country's first master's program in real estate development—"the first graduate program in the country that educates men and women for the full range of skills demanded of a developer," says the prospectus.

Real estate development has two characteristics that have delayed its achieving professional status:

☐ It encompasses a wide range of skills and disciplines—a truly multidisciplinary activity.

☐ At least some of its practitioners have received—and probably earned—a lot of bad press.

Continued on page A27

". . . More Skills to Deal with Complex Projects"

ROSALYN GERSTEIN

Question to Charles H. Spaulding, '51, by Elizabeth de Mille Barnett, graduate student in urban studies and planning: Why do you feel it's important to develop a strong relationship between developers and the university?

CHS: There is very little money spent on research in our business as compared to the medical, chemical, and electronics businesses, and yet shelter is one of the necessities of life. We need to give people more technical and management skills to deal with complex projects. The regulatory and environmental issues, to name only a few, need to be better understood by practitioners in the development business. Many people who go into the development business out of engineering, business, and architecture and planning schools do not have these skills.

EDMB: Do you think a lot of what a real estate developer needs to know can be learned on the job, or can you learn these things in school?

CHS: What you learn in school is a good grounding in skills, knowledge, and where answers can be found, and that's terribly important. But a center like this has the advantage of focussing these skills—and also of allowing people in the business world to come back and be updated. You'd be surprised how few managers in this field know how to use the computer, for instance. All the development firms that manage buildings have computerized their rent collections and that sort of thing, but a lot of analysis and forecasting still gets done by hand. I think our sort of graduate will have many opportunities and will be much much in demand.

EDMB: What do you think will be the major focus in the real estate field in the 1980s?

CHS: Well, I think the present rate of growth will continue in both the suburbs and downtown areas. While you can drive for miles and not pass a single home in some suburban areas and there appears to be an abundance of inexpensive land, development will continue to take place in or near where the infrastructure services are in place. Some of this growth will be hindered by the tremendous antigrowth feeling in the suburbs. To develop improved ways of dealing with issues that are critical to communities is another purpose of the center.

Classes

Gardner George, '11, a former mayor of Coconut Creek, Fla., was recognized last October along with 60 other pioneers of Broward County.

03

We have received belated and brief notices of the deaths of two classmates, **Mrs. Ferruccio Vitale** of New York, N.Y. and **Charles B. Cox** of 1200 Madison Ave., Wenatchee, Wash. on March 15, 1983. Mr. Cox was 102 years old. After graduating from M.I.T., he worked for the Reclamation Service, Grand Coulee Dam and the city of Portland, Ore. He also tried orcharding in Mabton and Sunnyside, Wash. He was a summer visitor of Brattleboro, Vt. from 1894 until 1953 and an avid fisherman of Vermont streams.

07

We have a word from Barbara (Mrs. **Maurice H.**) **Pease** of Naples, Fla. that her husband died August 6, 1983, at their summer home in Oak Bluffs, Martha's Vineyard, Mass., shortly before his 100th birthday. She says that he was remarkable in what he could do—at age 99 he was still tournament golfing.

Long associated with The Stanley Works, he had served the company for more than 35 years when he stepped down in 1949 as vice-president of the SW Steel Division. Even then, Mr. Pease retained his post as president of the Farmington River Power Co., an SW subsidiary, and remained as an SW director until 1964.

He also served on the board of New Britain Machine Co. for more than 25 years. He and his brother, the late Herbert H. Pease, president and board chairman of the local machine company, retired from the board together in 1965.

Mr. Pease may have been New Britain's oldest surviving veteran of World War I. He was a major in command of the 301st Engineers, a combat unit that served a year, 1916, in France. He helped form Eddy-Glover Post, American Legion, was a charter member and one of the post's earliest commanders.

For a number of years, in the 1950s and 1960s, Mr. Pease was the New Britain representative on the Metropolitan District Commission. He was also active in social and civic activities.

11

Gardner C. George writes, "Your kindess in remembering my 95th birthday is greatly appreciated. Your greetings brought to mind my M.I.T. years and the Class of 1911. I look in vain in each *Review* for news of the class. It would be wonderful if we could have news from all of the 1911 survivors."

Last Fall Mr. George was honored in a ceremony in Port Everglades, Fla. as one of 60 pioneers of Broward County. Mr. George worked on such projects as the Harlem Tunnel in New York City. He also worked for the New York State Highway Department and served as the chief engineer of the New York Power and Light Corp. in Albany from 1929 until 1951. Until 1962 Mr. George was a consultant to the federal government. He then retired to Florida and was elected the first mayor of Coconut Creek when the city was incorporated in 1967. Following that term in office, Mr. George served two additional terms on the city council.

We regret to report the following deaths: **George L. Bartlett** of Newport News, Va. on March 9, 1983; **G. Arthur Brown** of Fort Washington, Md. on October 31, 1982; **Lloyd C. Cooley** of Sarasota, Fla. on October 2, 1982; **Minot S. Dennett** of Chicago, Ill. on September 17, 1982; **Willis K. Hodgman, Jr.** of Taunton, Mass. on February 20, 1978; and **Walter C. Wilson** of Danvers, Mass. on December 21, 1982.

Walter Wilson was chairman of the board of Andrew Wilson Co. Under his direction the firm, initially formed as a roofing business and later expanded to become New England's largest producer of steel shelving and lockers, survived two World Wars, the Depression, and the exodus of the textile industry.

Mr. Wilson was very active in Lawrence, Mass. community affairs, and his leisure hour interests included golf and boating. He was also an avid traveler.

We have no further details on the other classmates but would like to extend condolences to all their family members.

16

Once again we are grateful to those who have taken the time to write us. From **Allen Pettee**: "At 94 I have no activities at all to report as my eyesight is almost gone." . . . **Dick Knowland** writes that he remembers and treasures our happy times at our reunions on Cape Cod, and wishes to pay tribute to **Harold Dodge** and **Ralph Fletcher**, our "brilliant and hard-working leaders." . . . **Charlie Reed** writes, "I have been thinking about the past reunions and have a story to tell the class before I attend by last reunion. I had decided that when the class had dwindled to 10 coming to the reunion I would tell the story, which is a dream. I dreamt that our class was meeting in Washington and that the '16ers were on a big old streetcar coming along 18th Street toward Columbia Rd. Their noise was terrific; arms and legs were dangling out the windows; M.I.T. songs were all mixed up together and it was the finale of a wonderful time for us all together. The streetcar came to a stop in the middle of Columbia Rd., and our classmates poured out the front door as best they could. Finally, the last man appeared; it was **Bob Wilson**. In sonorous voice he declared:

One-two-three-four,
Class adjourned forevermore.

It was in fact his last reunion. I never told Bob of my dream. . . ." Charlie also noted that he had a mild heart attack on his way to Maine which delayed him a month and a half, but he did enjoy a beautiful, restful summer at their cottage on Androscoggin Lake in Wayne, Maine, and that Millie kept busy taking care of him.

From **Harmon Keyes**: "My college work was completed at the University of Washington in Seattle after some delay. My degrees are all from the University of Washington: 1921, B.S. chemical engineering; 1922, M.S. in chemical engineering; 1924 professional degree of chemical engineer. The five years which elapsed prior to completion of student work was spent in mining and hydrometallurgy. . . . 1924-27, associate metallurgist, U.S. Bureau of Mines Experimental Station; University of Arizona campus. My subsequent work took me from Seattle to Mexico, Nicaragua, Gautemala and Cyprus Is. Much of my work involved metallurgical research in developing the autoxidation process for sculpture dioxide fixation to produce solutions of ferric sulphate and/or dilute sulphuric acid. To date I have taken out 13 U.S. patents plus one in Chile, all in the field of copper ore leaching."

From **Roy Sidelinger**: "In 1912, on a summer vacation in Maine, I met Margaret Chandler as she was starting nurses training at Augusta General. Six years later, 1918, we were married. In due time our two sons married and gave us seven grandchildren and to date, 12 great-grandchildren. My wife of 62 years died in 1981 and I retired to Maine a lonely widower for one year. I met the widow of an old friend. . . . We formed an alliance against loneliness and are now enjoying a second romance which has give us both a new lease on life." Roy entered the construction business after service in World War I, building many homes in Brighton, Cambridge, Wollaston, and Weymouth, Mass. He later joined Jordan Marsh and became its operation manager. In 1929 while still with Jordan Marsh he was appointed to the board of directors of the then Wollaston Cooperative Bank and now Colonial Federal Savings and Loan Association and served on that board for 50 years.

We are sorry to report the death of our good friend and classmate **Ken Sully** on April 1, 1983. May he rest in peace. . . . Keep eating, drinking, walking, breathing—everything in moderation and, of course, keep writing to us.—**Bob O'Brien**, Acting Secretary, H.E. Fletcher Co., Groton Rd., West Chelmsford, MA 01863

17

Many classmates have probably seen (on display at the Smithsonian Institution in Washington) the Spad XIII plane which was flown by **Ray Brooks** in World War I. It is the only Spad which still has its original fabric in place. Although the pilots in World War I were pioneers, a few of them set records as aces, and Ray Brooks was one of those aces. He reports that he doesn't have time enough to answer all the queries he receives from people who have seen his plane.

Notice has been received of the death of **Frank**

L. Butterworth on November 29 at Marion, Ind. His passing will recall to many Northfield Inn reunioners the duet piano playing of Frank and his wife, who survives.—**Walter J. Beadle,** Secretary, Kendal at Longwood, Box 217, Kennett Square, PA 19348

18

News wise this is the poorest time of the year for class notes—and this season is no exception. I am fortunate, however, to live within five miles of our alma mater, and to be able to take advantage of this proximity to enjoy the fruits as a member of the M.I.T. family. Perhaps a rundown of some of the events in which I recently participated will whet your appetite to do likewise to the extent you can.

Two months ago I attended a lecture by Professor Linclon Bloomfield of M.I.T.'s Department of Political Science on the subject—How do we coexsit in a world of diversity? The answer—the two world superpowers, the Soviet Union and the U.S.—can survive a first strike with the results that both countries become completely devastated along with most of the rest of the world. Therefore we have an uneasy world peace.

A few days later I heard a talk by Professor Ernest Cravalho of the Harvard/M.I.T. Division of Health Science and Technology. He told us of the many advances in health improvement research at M.I.T. involving blood plasma, replacement of arms and legs with mechanical ones, and so forth.

Additional lectures included one by John Reed, vice-chairman of Citicorp-Citibank, on financing international development and a talk by Professor Ed Roberts of the Sloan School on "The Secret of Success for Start-up High Tech Companies."

The M.I.T. Alumni Council recently had two good meetings. In October it was a tour of the new athletic facilities. Your eyes would have really opened wide to think back to our 1914-18 woefully inadequate athletic program.

Tonight I go to a Christmas party at the M.I.T. Museum. . . . All I can add is—I am lucky to be here to take in this exciting, educational, and stimulating M.I.T. atmosphere. I only wish all of you could join me and my Selma in this joyful participation.—**Max Seltzer,** Secretary, 1143 Beacon St., Brookline, MA 02146; **Leonard I. Levine,** Assistant Secretary, 519 Washington St., Brookline, MA 02146

19 65th Reunion

Over the years these class notes have reported many honors to members of our own class for their contributions to science and their particular professions. The latest such recognition is to **Robert B. MacMullin** who is a recipient of the 1983 Founders Award of the American Insitute of Chemical Engineers. Bob served 25 years with Mathieson Alkali Works, Inc. (now Olin Corp.) where he managed the research and development of such innovative products as High Test Hypochloritic (HTH), widely used as a purifying agent in swimming pools. In 1946, he founded R.B. MacMullin Associates which has been involved in the design, construction and rehabilitation of chemical and electrochemical plants all over the world.

I have been in touch with **George Michelson, Don Way,** and **Doc Flynn,** the other members of the Class Reunion Committee by phone and by correspondence, and we are all delighted with the number of classmates who hope to attend our 65th reunion in June 1984. We sincerely hope that all who can will make the sacrifice of travel and once more assemble as a group at the 65th. When you read these notes you will already have received a "reminder" with some particulars as to our plans.

See you at our 65th.—**W.O. Langille,** Secretary, Box 144, Gladstone, NJ 07934

20

Word from **Karl Bean** of South Yarmouth and **Ming Pai** of Washington, D.C. indicate that they are alive and kicking. Ming says he does a lot of reading—up to six hours a day.

I regret to report the death of **Mendum B. Littlefield** of Larchmont, N.Y. on July 7 this year. M.B. in his early years lived in Salem and on Bakers Island near Salem. He served with the Navy in World War I and had a long career as a mining engineer associated with Guggenheim Brothers of New York. He previously worked for American Smelting and Refining Co. He was an active member of the American Institute of Mining Engineers and the Mining Club of New York. An avid sailor he was a member of the Larchmont Yacht Club and Cruising Club of America. He built the 52-foot schooner, *Black Fish* in which he sailed for a quarter century. He is survived by a son and two daughters.—**Harold Bugbee,** Secretary, 21 Everell Rd., Winchester, MA 01890

21

Our class president **Carole A. Clarke** was honored on October 27, 1983 when the national chairwoman of the Daughters of the American Revolution presented him with the DAR medal of honor for "leadership, trustworthiness, service and patriotism." This award is made about once a year in New Jersey and was presented during the autumn meeting of the New jersey DAR at the Hyatt Regency in New Brunswick. The award was given in recognition of a ten-year series of "Bicentennial Briefs," published in the *Coast Star*, Manasquan, N.J., in which Cac chronicled the daily struggle of the American colonists in their fight against British rule between 1773 and 1783.

In Brielle, Cac was co-chairman of the Bicentennial Committee. He founded the Union Landing Historical Society and was its first president; is borough historian and a member of the Monmouth Country Heritage Committee; was a former vice-president of the Brielle Library board of trustees; and was involved in other historical organizations. Cac still works three days a week for the *Coast Star*. He was awarded the Alumni Association's highest honor, the Bronze Beaver, when the award was established in 1955. He was awarded the Silver Beaver by the Boy Scouts of America in Glen Ridge, N.J., in 1957. He was one of six founding members of the M.I.T. Club of Northern New Jersey, a past president and the recipient of the club's Outstanding Alumnus Award. Cac holds a half dozen patents and is the co-author of the Prentice-Hall *Handbook of Electronic Instruments and Measurement Techniques*. . . . Cac we salute you!

News of one death was received this month: **Harry M. Ramsay** of Tucson, Ariz., on May 12, 1983. A letter from his wife said he had been in the hospital for surgery since December 28, 1982, and was due to return home on May 14, but suffered a heart attack. During his business career Harry was president of the Wholesale Tire and Supply Co. of Minneapolis. Our sympathy is extended to his wife, Margaret.

That's all the news we have this month so please, all of you, write us. Our job is easy if we have no news, so help us make our job a little harder.—**Sumner Hayward,** Secretary, 224 Richards Rd., Ridgewood, NJ 07450; **Josiah D. Crosby,** Assistant Secretary, 3310 Sheffield Cir., Sarasota, FL 33679; **Samuel E. Lunden,** Assistant Secretary, 1149 S. Broadway, Suite B-800, Los Angeles, CA 90015

22

Whitworth Ferguson, class secretary from 1957 until last year, died November 2, 1983 at age 83 after a lingering decline following an accidental fall in 1982. Whit was a graduate student with a teaching fellowship at the Institute, after receiving a B.S. in electrical engineering from Iowa State University in 1921. He received no degree from M.I.T. Fortunately, however, he elected to become affiliated with 1922 and gradually, by his enthusiastic work in M.I.T. affairs, became a full-fledged classmate.

Whit was an extraordinarily able man, very successful in operating his companies, Ferguson Electric Construction Co. and Ferguson Electric Equipment Corp. with several hundred employees. He was a leader in many civic projects and generously contributed to M.I.T. The following citations from *Who's Who in America* reflect some of his activities over the years: chairman, Buffalo Branch of the Federal Reserve Bank, director, Erie Lackawana R.R. Co., Buffalo Insurance Co., Buffalo YMCA, Allbright Art Gallery; vice-president and director of Delnite Mines, Ltd. of Canada; vice-chairman, N.Y. State Atomic and Space Development Authority; deputy director, Erie County Civil Defense; trustee, Hospital Service Corp. of Buffalo and Millard Fillmore Hospital; and president, Buffalo Chamber of Commerce.

During World War II, he served as colonel in the air force. He was also a member of the M.I.T. Future Planning Committee. He is survived by his wife of 59 years Dorothy, a daughter Barbara F. Federlein, and two sons Whitworth, Jr. and Donald R., to whom we extend our appreciation of Whit's fine service to the Institute and our class.

Haywood P. Cavarly, Jr., age 83, of Daytona Beach, Fla. died June 25, 1983. After working for Brooklyn Edison and Consolidated Edison of New York, he founded Lakeside Construction Co. in Lakeside, Conn. in 1945, retiring to Florida in 1961. He is survived by his wife Mary, a son, and one granddaughter. . . . **William J. Edmonds,** died July 1, 1983 while on vacation in France. He had been vice-president of Caret and Co. of New York City. His retirement home was in Naples, Fla. He is survived by his daughter, Mrs. Nancy E. Luce of Rye, N.Y. Mrs. Luce wrote that many friends of her father had requested information concerning donations to M.I.T. in his memory or establishing a scholarship fund in his name. The matter was referred to Joseph S. Collins, director of the Alumni Fund.

A recent letter from Charlotte McGrady Mayfield, daughter of **Charles T. McGrady,** advises that her father died May 15, 1983 at age 84. He had suffered from Alzheimer's disease for over 30 years. I believe he had earlier practiced as a petroleum engineer with Barber Oil Corp. of Houston. . . . **Edward L. Norton,** age 84, who entered M.I.T. his junior year, died January 28, 1983 at his home in Summit, N.J. Prior to retirement, he had been with the Bell Labs in Murray Hill, N.J. as a data transmission engineer. No word as to survivors.

Roland H. Becker, age 82, died May 13, 1983 in St. Petersburg, Fla. Becker was the successful owner of Becker Construction Co. in Milwaukee from which he permanently retired in 1968. He was a widely-known yachtsman in Florida racing. He raced in the Southern Ocean Racing Conference yearly until 1975 and three times in the Bermuda race. Prior to going to Florida, he competed for over 25 years in the Chicago-Mackinac race. Becker is survived by his wife, two daughters, and seven grandchildren.

Vice-admiral **Frank E. Beatty** died sometime in 1982. Details are not available. . . . A letter in October from **William W.K. Freeman** tells of the death of his wife Betty on September 26, 1983, after 55 years of marriage. Mrs. Freeman (nee Elizabeth Bull) was Class of 1920, Wellesley. In addition to her husband, she is survived by two daughters (also Wellesley graduates) and a son.

The Bronze Beaver award to **"Mac" McCurdy,** which he received last September 24, read in part: "For all of his 60 years as an alumnus, 'Mac' McCurdy, 'Mr. M.I.T. of the Puget Sound,' has generously endowed and staunchly supported M.I.T. Crew, an M.I.T. varsity sport which he founded and which he captained in his senior

year. He has been an M.I.T. club president, M.I.T. honorary secretary for the Pacific Northwest (a position he held for 34 years), a member of the Alumni Association's National Nominating Committee, member of seven Corporation Visiting Committees, and is a life member emeritus of the M.I.T. Corporation. For 20 years he had been vice-president of his class, and he has been involved in every major fund-raising campaign since 1949." We are glad Mac has survived long enough to receive the Beaver in person. The award was long overdue. In the fall 1983 *Forbes* special edition, "The Richest People in America," we find under the duPont column, "Irene Sophie [Mrs. **Ernest May**]: Wilmington, Del. Married, four children. Husband considered family radical (supported Castro), fought family's effort to reduce tax on Irenee Sr.'s estate. Margaretta [Mrs. **Crawford H. Greenewalt**]: Greenville, Del. Married, three children. Husband most successful du Pont in-law—DuPont Co. president 1948-62, present with Fermi at first controlled nuclear reaction in Chicago in 1942." The column closed with: "The eight siblings and their immediate families share in father's fortune worth at least $1.2 billion today." **Tubby Rogers** should take a bow.

In the October 10-23, 1983 *Mass High Tech* is the following taken from a longish article discussing the shortcomings of the metric system based on a recent talk by **Bill Elmer** to IEEE engineers at Arthur D. Little, Inc. "Dr. David Goldman, acting director of the Office of Metric Programs in the U.S. Department of Commerce had an opportunity to speak with Elmer who is proposing that we make life just a little bit easier by compromising between the English Standard of measurement we now use and the metric system. 'I get a lot of such proposals,' noted Goldman. 'Actually, Elmer's is one of the most sensible.' "

Dr. Goldman concludes by saying, "The metric system is in use worldwide except for the United States and a couple of minor countries. There is just no way the rest of the world is going to change, and that's where I think Mr. Elmer's proposal falls. To which Bill responds, "There are fundamental reasons why change to the metric system will never occur in the U.S."

A note from **William L. Hawes**: "Following my retirement from Union Carbide in 1963, my wife and I spent nine months in Europe. We took a 12-month trip around the world in 1969-70 and have lived in a retirement home in Silver Springs, Md. since 1972.—**Yardley Chittick,** Secretary, Box 390, Ossipee, NH 03864

23

Thirty-eight copies of the *Great Historian* remain on deposit at the M.I.T. Museum after selling 14 class members and awarding 10 to widows and 11 to administrative offices. These included Howard W. Johnson, chairman emeritus of the Corporation; David S. Saxon, chairman of the Corporation; Jerome B. Wiesner, president emeritus; James R. Killian, president emeritus; Paul E. Gray, president; Vincent A. Fulmer, secretary; Joseph J. Snyder, treasurer emeritus; Robert W. Mann, president, Alumni Association; Shirley M. Picardi, secretary, Alumni Assocation; Joseph J. Martori, associate secretary, Alumni Association; and Janet S. Lambert, in charge of our 60th.

"It is truly a great history of a great class," said Vince Fulmer in his acknowledgement. "It makes me swell with pride." Copies are still available for class members at $5 or as gifts to widows.

Mrs. **Laurence Noble** writes that she spent the month of August as usual at Grand Lake, Colo. and has just returned from California where she attended the wedding (at the Redwoods) of her younger grandson. The older one was married two years ago. . . . **Ragnar D. Naess** writes that he is having a great time being retired, that he is a trustee of Marlboro College (for about 20 years now), a trustee of the American Scandinavian Foundation, a director of Insurance Co. of America, Life Insurance Co. of New York, and of Naess and Thomas Special Fund, a mutual fund investing in small companies. He still likes to ski, sail, and play the piano.

Established with a million-dollar gift in 1974, the Ida M. Green, '23, fellowships give first preference to women graduate students. The 1983-84 fellows with their benefactors are (from left) Leslie A. Sundt, Paula C. Garfield, Jennifer S. Cole, Ida M. Green, Cecil H. Green, Priscilla K. Gray, President Paul E. Gray, Lois Pollack, Phyllis R. Berg, and Tanya H. Furman. The fellowships have so far benefitted 75 women at M.I.T. (*Photo: Calvin Campbell*)

E. Bartlett Cooke received the 1982 Pitts Award, the highest honor of the Texas Society of Architects (TSA), at the Society's 43rd annual meeting on November 5, 1982. It is presented for outstanding contributions to the profession of architecture. Cooke was instrumental in the founding of TSA in 1927. In that year also he was elected to the AIA College of Fellows.—**Richard H. Frazier,** Secretary-Treasurer, 7 Summit Ave., Winchester, MA 01890

24 60th Reunion

Your 60th Reunion Committee consisting of **Don Moore** (chairman), **Herb Stewart, Ray Lehrer, Don Fife, Dick Shea,** and **Russ Ambach** held its nth meeting on November 9, 1983 at the Algonquin Club in Boston, thanks to the gracious hospitality of **Ray Lehrer**. Joe Martori, associate secretary of the Alumni Association, was our guest and answer man. Plans for June 7-9 were pretty well finalized, so by now you should have received the results in a letter. The chief items are that our headquarters will be the Sonesta Hotel, Memorial Drive, Cambridge, and the guest speaker during the Saturday night banquet at the new Westin Hotel in Boston will be our honorary classmate, **Dr. Irwin Sizer,** formerly biology department head for ten years.

Charles E. Herrstrom passed way September 1, 1982 in Sarasota, Fla. He gained his S.B. in chemical engineering and added a bachelor of law from George Washington University. Charlie was a patent attorney for several firms and became a partner in the patent law firm of Bosworth, Herrstrom, Sessions, and Knowles, Cleveland, Ohio. He was a member of the executive committee of the M.I.T. Post Army Ordance Association and entered active duty in 1942, being relieved as a colonel in 1946. He retired to Florida circa 1968, after becoming chief patent counsel, Reconstruction Finance Corp.

Edith A. Reid writes that **Ralph A. Reid,** her husband, died September 7, 1983 in Hendersonville, N.C. He earned his S.B. and S.M. in VI-A, electrical engineering cooperative. He joined General Electric in design of Traffic Controllers and in 1941 became administrative assistant to the division head of the aircraft gas turbine division, subsequently retiring to North Carolina.

A note and clipping from Edwin E. Hebb, '48, records the death of **Everett V. Martin** of Dearborn, Mich. He died suddenly on September 23, 1983, while at a family reunion on the West Coast. He was awarded an S.B. in mechanical engineering, having prepared at Westminster College. His career included terms with Republic and Carnegie Steel, Firestone Tire and Rubber, and Great Lakes Steel Corp., Detroit, Mich.

A note from **Clint Conway**: "We are moving October 24 to Lakeview Terrace Retirement Center, P.O. Drawer 400, Altoona, FL 32702, (904)669-4024. Our phone number listed in a recent *Review* is incorrect. We shall be near Epcot and Disney World and 100 miles closer to New England for our travels. This is near Orlando, if you have an Alumni Club there."

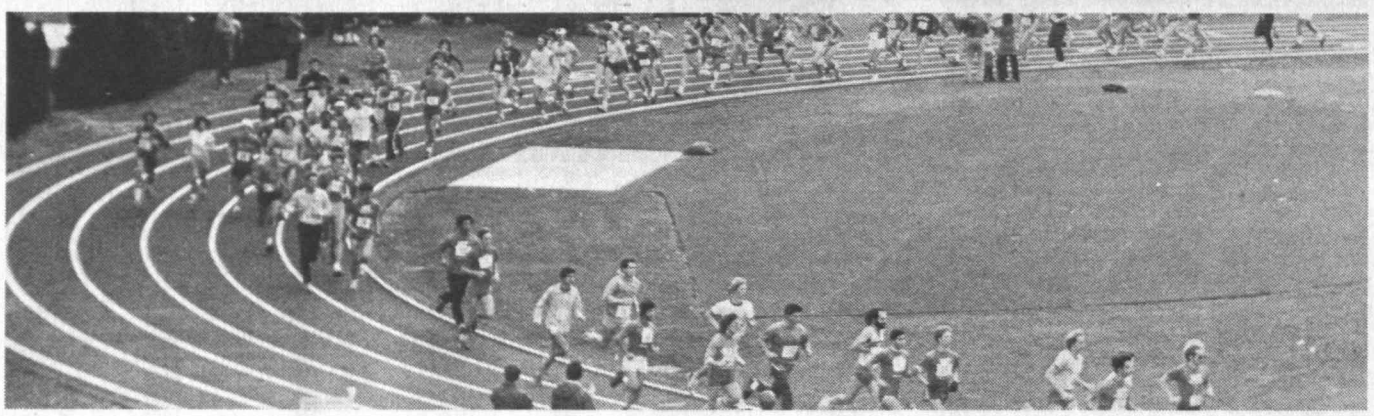
R. Bruce Lindsay has taken up his pen or word processor again for a recent publication, *Energy in Atomic Physics, 1925-1960* by Hutchinson Ross Publishing Co., Stroudsburg, Pa., 1983.—Co-Secretaries: **Russ Ambach,** 216 St. Paul St., Brookline, MA 02146; **Herbert R. Stewart,** 8 Pilgrim Rd., Waban, MA 02168

25

Several classmates have reported in during the past few weeks and your secretary certainly appreciates hearing from 1925ers. **Gil Delugach** writes from Memphis, Tennessee. This past summer he and Gertrude spent two weeks driving through southern France with their younger

At the dedication of the Henry G. Steinbrenner, '27, stadium in April 1978 (right), Mr. Steinbrenner asked that M.I.T.'s future athletes "realize that the most important thing is not to have conquered but to have fought well."

Last November (below) the first M.I.T. Women and Friends Road Race was run in Steinbrenner Stadium. More than 150 Women and men entered the five-kilometer race.



daughter and son-in-law. Found it an easy trip with someone to do all the driving. Gil celebrated his 80th birthday in December and they took a Caribbean cruise with children and grandchildren. They expected to spend January in Boca Raton. **Fred Greer** writes to tell us that he has moved again. This time to a fine retirement home about two miles from their Gulf Shore Blvd. apartment. The new address is 122 Moorings Park Drive, Apt. 712, Naples, Florida 33942. This is a new development and a move seemed appropriate while they could have a good choice of apartments. From the 7th floor they look out over the golf course where Fred played for almost 10 years. Fred was always an excellent golfer but for the past 8 years has had a bad back which prevents his golfing. The Greers had a summer home in New London, New Hampshire which they had used for many years but they sold it and will spend most of each year in Florida. They hope to get up to the Boston area to see new members of the tribe. They now have 6 great-grandchildren. **Milt Salzman** writes and reminds us that he has missed the last three Alumni Day celebrations resulting from his wife Lillian's invalidism. Milt and his son Roy, M.I.T. '55, celebrated their mutual birthdays last September 25th at Lynbrook, N.Y. Milt became an octagenarian and Roy a mid-Centenarian. They had a partial family reunion and the Nassau Mid Island Barbershop Chorus group joined them for musical festivities. Milt and Roy participated with a duet rendition of "Take Me Back to Tech." A note via the Alumni Fund Office comes from **Charles E. Peterson** of Athol, Idaho informing us of some of his travels—3 weeks in China with an American Railway Delegation and 6 weeks in Scandanavia, Greece and Italy. All of you have received a letter from Harrison Browning reminding you of the nearing 60th Reunion year and our hopes for a fine Reunion Gift for M.I.T.

Local M.I.T. activities have found classmates in attendance. Evelyn and I joined M.I.T. Cape Codders at the fall meeting of the Cape Cod Club and Muriel and **William Stone** were also there. **Ed McLaughlin** was at the Senior Alumni gathering at Endicott House on October 16 and reported that Elinor and **Sam Spiker** and the Stones were there. I made the first Alumni Council meeting of the season on October 17 and was joined there by **Ed McLaughlin** and **Courtenay Worthington**.

It is with sorrow that the passing of two classmates must be reported. **Ira D. Chambers** died in Scottsdale, Arizona on January 26, 1983 and **Paul E. Hess** died in Montgomery, Alabama on September 28, 1983. No details are available at this time.—**F. Leroy (Doc) Foster**, Secretary, 434 Old Comers Road, P.O. Box 331, North Chatham, MA 02650

26

On October 12th the M.I.T. Libraries sponsored a lecture by our classmate **I. Austin Kelly, III** on "The Love of the Book" with an exhibition of volumes from the Kelly collection of rare books. Austin, as Curator of Rare Books, M.I.T. Libraries, has also been most generous in contributions of his own collection. On October 16 the Cardinal and Gray Society led by our **Bob Dawes** continued the series of luncheon-lectures at Endicott House with Professor Ernest G. Cravalho discussing health sciences and technology at M.I.T. These affairs have been both successful and interesting with more than one hundred guests attending.

Eben Haskell writes of a recent attendance to a memorial service in Barnstable, Massachusetts for Harriet Chase, wife of our classmate **Don Chase**. Harriet had attended with Don all our recent reunions on the Cape and made many friends among our classmates and wives. The Haskells and the **Al Libbeys** had stayed with the Chases at their lovely home in Harwichport during the last three reunions. Eben reports almost complete recovery from an eye operation reported in our October notes. A note from **Dwight Woods**: "Clemmie and I are still well and happy. Looking forward to spending two months this winter at South Padre Island in our trailer meeting old friends from all over the country and getting some salt water surf fishing. Also doing some shopping and eating in Matamoros, Mexico." . . . Last week (Nov. 14) we had the pleasure of a visit from **Pietro Bellaschi** who came on from Oregon for a consultation at the Lahey Clinical Medical center. Peter, appearing in the best of health and spirits regaled Evelyn and me with tales of his worldwide experiences with his family on the many occasions of his attendance and lectures at conferences on High Voltage developments in which he has led during the past 50 years. He is still very active as a professional consultant and is currently submitting documents for review at the Centennial of the IEEE. **Don Cunningham** called recently after his return from a trip to China with the M.I.T. Quarter Century Club. A later note from Don tells of the trip: "We visited eight cities in China, then Hong Kong. Len Newton '49 was our guide. He had the experience of living in China one year, immediately after World War II while in uniform, and leading a similar tour in 1981. One of the eighteen local alumni we met in Peking was Prof. C.Y. Shih '26. He is at Tsinghua University. I tried to sell him on coming to our 60th Reunion. We also had excellent meetings in Shanghai and Canton. These Alumni are now very important people in the new China, but they all suffered a few years ago due to the "Gang of Four." The people are unusually friendly, many are studying English which is taught on TV and they will come up to strangers to try out their English."

The Computer-Aided Control System Symposium held at M.I.T. recently was opened by remarks from our Doc Draper, followed by a roster of international technical speakers. The intensity of Doc's professional activities would put to

shame those of many years his junior. We have just received a very nice note from Katherine, daughter of **Dave Shepard**. She had recently returned from a tour of Europe in which she had been acting in a play, and was able to attend a memorial service in Denver at which Dave's ashes were deposited with his wife's.

Our apologies for an error in the October, 1983 notes concerning the passing of **James B. Powers** which we had interpreted as **David B.** who called recently to correct insisting that he intended to attend the 60th reunion and any others scheduled thereafter.

The Boston Globe published an article concerning the death on October 24 of **Walter E. Campbell** of Nelson, N.H., a retired Boston architect who had headed the firm of Campbell & Aldrich. His buildings included the First National Bank high rise in Boston and its Data Processing Center in Dorchester, the U.S. Embassy in Taiwan and many other well-known educational and institutional structures. In addition he had served in an official capacity on many committees of the American Institute of Architects and many groups of public service activities. His many talents included artistic expression as water colorist with many exhibits, and his support of creative writers, painters, musicians, actors and poets through the St. Botolph Foundation established in 1963. His wife, the former Loraine Leeson died last year and he leaves three sons, Leeson of Dedham, Dix of Belmont and Charles L. of Colorado Springs, Colo.; a brother, Orwwod J. of Claremont, Cal. and six grandchildren.

Another notice, without further information, is of the death on September 26 of **Col. Donald C. Hill** of 6100 Bivens Ct., Norfolk, VA 23518.—**William Meehan**, Secretary, 191 Dorset Rd., Waban, MA 02168

27

Your Secretary has received an enlightening letter from **Harry E. Franks** of Chestnut Hill, Mass. excerpts of which follow: "Yesterday, I received my *Tech Review*, and as usual, the first thing I look for is the news of our class, and as usual all that is reported is the trips made by our classmates, who dies and mostly mundane factual data. Constructively speaking, what I and probably many others would like to learn would be something meatier and more active on-going experiences of our classmates.

"Re the enclosed resume, and profile, this is all self evident and is the sort of thing I mentioned above. However I am now in the process of selling the laser Division on account of my age and the day duties and responsibilities. I am planning to operate the spark plug operation now. The press release will give you the story on how this was created and developed.

"This is the kind of reporting that our classmates would really enjoy knowing about if we can get them to give it to you. How can we get them to do this?"

Francis (Sailor) T. Cahill died on June 29, 1983 in North Eastham, Mass. An architect, he worked for Boston Naval Shipyard Design Division from 1938-1962. Files show he won the Irish Sweeps on a 66-1 chance in 1963 and has been retired since then.

Frank G. Kear died on July 22, 1983 in Sunnyvale Calif. He had suffered from Alzheimers disease for four and a half years. Frank joined the National Bureau of Standards in 1928, in 1933 was Chief Engineer of the Washington Institute of Technology. During World War II he was chief of the radio section in the Bureau of Aeronautics. Frank was a Consulting Engineer in Washington for many years. He was a member in 1976 of a task force for directional antennas, interference and other factors for world-wide radio communication.

Henry G. Steinbrenner died on November 7, 1983 in Westlake, Ohio. One of our most illustrious and accomplished classmates, Hank was a star on our track team, twice winning All-American recognition. His most memorable victory came in his final meet for M.I.T. in Philadelphia in May 1927 when he won the national Collegiate 220 yard low hurdles Championship in a record time of 23.9 seconds. He graduated with a B.S. in Naval Architecture and Engineering and also won the American Bureau of Shipping Award for outstanding achievement. He attended R.O.T.C. Camp Humpfreys Va. for Army Engineers and I recall he and **Hall Hately** (now living in San Juan) were the Mutt and Jeff of the Company. Hank continued his Commission and in World War II was Lt. Com. in the Coast Guard Reserves.

In April 1978, M.I.T. dedicated its new track and field stadium that his family gave to M.I.T. in his name in honor of his achievements. (Everyone knows that his son George is the proud owner of the N.Y. Yankees.) Hank came from a pioneer family in the Great Lakes shipping industry, owned one of the few independent fleets that survived when Great Lakes shipping declined in the 1960's. He served as President of Kinsman Transit Co. from 1947 to 1963, and was recognized as one of the most astute shipping executives. In 1968, he was presented the Great Lakes Man-of-the-Year Award, the highest award offered by the maritime industry. His life motto was "Always work as hard as, or harder than, anyone who works for you."

After his son George purchased Kinsman Transit in 1963, his father continued to serve the company as an officer and advisor until 1979.

Hank was a modest, hard driving, friendly classmate, a great benefactor to all M.I.T. athletes for years to come.—**Joseph C. Burley**, Secretary, 5 Hutchinson St., Milton, MA 02186; **Lawrence B. Grew**, Associate Secretary, 21 Yowago Ave., Branford, CT 06405; **Prentiss I. Cole**, Associate Secretary, 2150 Webster St., Palo Alto, CA 94301

28

The Cardinal and Gray Society is an informal group of the more senior Institute alumni(ae) who reside within easy-travel distance of the Boston/Cambridge area. More specifically, members generally are from those classes that have been out 50 years or more. Widowed spouses are included. The fall meeting of this group was held at Endicott House in Dedham, Mass. on October 16, 1983 (a beautiful day) with about 130 in attendance. Our class made a good showing with the following listed: **Hugh Bean,** Marjorie (Mrs. **John A.**) **Carvalho,** Marie and **George Chatfield,** Frannie and **Jim Donovan, Bill Hall,** Julie and **Paul Martini,** Dorothy and **Gus Rogowsky,** Florence and **Walter Smith**. After an excellent luncheon, we had a most interesting talk by M.I.T.'s Professor Ernest Cravalho.

A note from Velma and **Charlie Worthen** describes the neighborhood where they live in San Jose, Calif. Theirs is one village in a group of four. The dwelling types there are both single houses and condominiums with everything nicely landscaped. Streets are named for various wines—they live on Riesling Way. . . . **Phil Taylor** writes that he was in the hospital for a hernia repair. The damage was caused by a rough climb and fall right in his hometown. He had been in recent telephone communication with Maragret and **Charlie Southwick,** who were planning to leave for England in September. . . Gertrude and **Bob Peatfield** expressed regret at having to miss the 55th but were pleased with the memorabilia items they received. They saw Gladys and **Dave Olken** later and had from them a good report on the reunion. . . . Other reunion inspired notes have come from Dorothy and **Bob Cook,** Claire and **Ted Pierce** and **Hy Weinberg**.

Gabe Disario tells us that 1983 was election year in Venezuela and that one of the intense campaign points was the foreign debt which has caused economic hardship for his country. . . . During our (the Smiths') annual trip to Maine in late Fall, Florence and I were in Fryeburg where we visited with **Jim Tully** and had a pleasant evening with Priscilla and **Roger Haven**. We also had a nice telephone chat with **Ernie Knight** in nearby Raymond, Me.

With deep regret we must report the deaths of four of our classmates. **Stewart H. Newland** died on November 16, 1983. We had a letter from Stew's wife Libby and a telephone call from his son Stewart, Jr. telling us the sad news. Libby expressed how very much she and Stew had enjoyed the 55th reunion and, later, the beautiful group picture in color. Then in late August Stew suffered a major stroke, and his condition deteriorated after that. Since his retirement from business in 1972, Stew and Libby enjoyed life by trailering about the United States. . . . **Edwin F. Celette** died September 27, 1983. Ed graduated in chemical engineering and for much of his professional life was in the dyeing and finishing aspects of the textile business. Ed's wife, Eloise, notified us of his death.

Malcolm Mitchell died August 21, 1983. Malcolm received his S.M. in fuel and gas engineering, Department of Chemical Engineering, and during his professional years was with Reilly Tar and Chemical Corp., Indianapolis, Ind. . . . **Joseph K. Roberts** died on April 3, 1983. Joseph received his S.M. in chemical engineering and for most of his professional life was with Standard Oil Co. of Indiana where he became manager of research and a director. In his later years he did consulting work. . . . We extend our heartfelt sympathy to the families of these classmates.—**Walter J. Smith,** Secretary, 37 Dix St., Winchester, MA 01890

29 55th Reunion

Correction: Reference to the passing of **John Saloma** was incorrectly placed in this column in the November/December issue. It was, however correctly noted for John S. Saloma III, '56, in the October issue of the *Review*.

Al Moore of Rockville Centre, N.Y., writes, "Thanks for your usual birthday card which I appreciated this year more than ever. In late April I developed a new type of stomach ache and three local doctors had a 'field day' performing three unrelated operations on me during most of May and June. My friends tell me how lucky I am to have survived the ordeal and how I can look forward to living to a ripe old age instead of the measley 75 years I am now. Regards to all." Al indicates that he will be attending our 55th reunion next June.

I have a brief note from **Arthur Bearse** of Gloucester, Mass., who sent me a booklet on how to prepare and cook squids (Calamary) which he claims are delicious, "taste like fried clams." "A recent news item," he continues, "states that the annual engineering cost for one year at M.I.T. has reached the staggering amount of $15,130 which is a far cry from our undergraduate days. I am not sure I'll be able to attend our 55th reunion as we are going to leave our family car in Florida, and transportation to the Cape and back will be a problem." Arthur and his pal, Pat Cilley of Sharon, Mass., have not missed attending Technology Day for many years. I look forward to seeing them every year.

Howard Pankratz of Riverside, Calif. writes "Margaret and I are watching the Miss America Contest on TV. My afternoon nap became a long rest, from 3:30 to 7:30 p.m., without the very sharp and continual pains which have been with me since August 1981. If you think my phone calls are too long and too costly, just consider them as therapy. I am rather a physical wreck, confined to a wheelchair, canes, walkers, and crutches, and such phone calls to classmates like you, **Hunter Rause, Bill Bowie, Jerry Gardner, Dexter Osgood,** and others give my spirits a needed lift. I sent my reply to Jerry Gardner stating that if I am allowed to attend the 55th it will have to be with two male nurses to carry me around and get me in and out of bed, plus a

nurse to give me injections for diabetic ulcers, etc. I would rather contribute the cost to the Alumni Fund which will do lots more good than my attendance at the reunion. I know that you, **Len Peskin** and some other intimate friends do not believe that my financial resources are considerable. Just for example, I purchased 100 shares of Caterpillar Tractor Co. in 1932 for $3.75/share and, through growth and re-investment of dividends, they presently have become 72,546 shares."

A note from **Eric A. Bianchi** of Tequesta, Fla., reads, "Thank you for your 1983 birthday greetings and your sincere expression of sympathy. Yes, life is different after losing a loved one to whom you have been married for 51 years. Kay passed away on May 22, after a brief bout with cancer, which developed in her right lung and then spread rapidly to other areas. Her passing was truly a blessing, considering there was no alternative. My health and activities continue to be about the same, except I have just gone through a cataract and lens removal and the implant of a replacement lens. That operation these days is relatively simple—no overnight hospital stay and no after effects if you follow medical ground rules. I expect to have a marked improvement in my sight which will allow me to enjoy getting back playing golf and being able to follow the flight of the ball. I made a brief trip up north this summer which included a stay at Bald Peak Colony Club and another great reunion with Joan and **Wally Gale**. I trust you and Helen are well and will stay that way."

Angelo M. Altieri and his wife Rose of Watertown, Mass. are enjoying their retirement years with good health. His hobbies are gardening and travel. They have two daughters and seven grandchildren. . . . **G.J. Guthrie Nicholson** and his wife Klara of Portsmouth, R.I., are well and enjoying their retirement years. They are planning to attend our 55th reunion next June. They have three children and five grandchildren. . . . **Edward B. Papenfus** and wife Gwen of Vancouver, B.C., are well and spend winter months in South Africa and the rest of the time in Canada. They plan to visit continental Europe this autumn (1983) and possibly New Zealand during the winter of 1984. Ed still believes that the inflation is not totally cured, and being a "gold bug" believes in the precious metals rather than paper currency. They have three children and two grandchildren.

By the time you read these class notes, you most likely will have received a follow-up letter from **Jerry Gardner,** general chairman of our 55th reunion, June 3-7, at Chatham Bars Inn (the Cape) giving you additional details of the great event. A goodly number of your classmates have already signed up and if you are on the "fence," get down and send your positive reply. I am sure you will have a good time plus added memories of a great institution and a great class, 1929.—**Karnig S. Dinjian,** Secretary, P.O. Box 83, Arlington, MA 02174

30

This issue's Note's are being written the day before Louise and I leave on a month-long freighter cruise to Ecuador and hence will necessarily be rather brief. We sail tomorrow afternoon from Philadelphia on Delta Lines' *Santa Rosa*. I'll report on the trip next month. . . . **Doug MacDonald** retired in 1968 as regional manager for the London Life Insurance Co. in Ontario, Canada and now lives in Nassau in the Bahamas. He and Adelaide are both ancient history and archeology buffs, and over a period of years have re-traced the paths of the Roman legions through most of western Europe to England and Scotland. Next year's installment will include Corsica, Sardinia, Sicily, and Carthage, the N. African city that after three wars the Romans completely destroyed and then ploughed with salt to ensure its permanent extinction. . . . **Jim Merrill** retired 20 years ago as assistant research director of Goodyear to indulge his interest in conservation experiments on a 20-acre tract of farmland and woodland near Akron. In a recent report he describes his current activities very tersely as "gentleman farmer."

After retiring as an engineer from New England Power Service Co. in 1970, **Allan McLennan** did consulting work as an electrical engineer for Charles T. Main for a number of years. His consulting work took him to Australia, Brazil, Hawaii, Iran and Panama. He is now fully retired and spends winters in Wakefield, Mass. and summers in Boothbay, Me. . . . **John Moriaty** retired from Gulf Oil in 1973, and he and Etta now live in Port Arthur, Tex. His retirement activities include delivering "meals on wheels" to "aged shut-ins" (presumably more aged than we are), as well as hunting and fishing. He and his brother-in-law on a recent two-day fishing trip to Toledo Bend Lake caught 54 bass, quite close to the limit of 15 per day per fisherman.—**Gordon K. Lister,** 294-B Heritage Village, Southbury, CT 06488

31

Last issue, we read excerpts from *Selected Papers of* **J. Kazuo Minami**, which John's colleagues at Wasada University published on the occasion of his retirement at age 70. Now we have a letter from John describing his recent activities: "My life in retirement since 1978 has been uneventful. The Emperor of Japan conferred on me the Third Class Order of the Sacred Treasure in 1979 for my contribution to education, and I have been made an honorary member of several engineering societies—International Association for Earthquake Engineering, Japan Society for Soil Mechanics and Foundation Engineering. I have written several articles on foundation and earthquake engineering since then on request. With advancing age, I am getting ready for the final call to return to the dust by making arrangements so that my wife, Yoshiko, may live comfortably after I am gone, when my son Tadao (now associate professor at Tsukuba University) becomes the titular head of our family. The 8th World Conference on Earthquake Engineering is scheduled in July, 1984, at San Francisco, and Yoshiko and I would like to attend if I am feeling strong enough. Tad, who is also involved in earthquake engineering, will be going on his own, or possibly as my proxy. Elenora and **F. David Schweizer** celebrated their Golden Wedding anniversary in June this summer and we were happy to extend best wishes to them." John's address is 4-28-8 Hakusan Bunkyo-Ku, Tokyo 112, Japan.

A note from **Ben Steverman**: "The enclosed list of attendees at the Cardinal and Gray Luncheon shows that the Class of 1931 was well represented. We were blessed with a beautiful fall day, and we enjoyed each other's company along with a fine presentation by Professor Cravalho on health sciences and technology at M.I.T. While our 55th Reunion is too far away for specific planning, we had an opportunity to exchange a few ideas on the way to get the most out of the few precious days we will have in June, 1986. Any and all comments and suggestions from all classmates we can contact will be most welcome." According to the list of attendees published by the Cardinal and Gray Society, the following classmates attended the luncheon: **Larry Barnard**, **Eugene C. Branca**, **Mrs. Vincent F. Damiano**, **Kenneth Germeshausen**, **Ed Hubbard**, **George Manter**, **Charles W. Seaver**, **Donald Sinclair** and **Ben Steverman**.

John Swanton writes, "I must report a gathering of three classmates on the coast of Maine in September. Louise and I had gone to Washington the week before to join in the delightful celebration of Loretta and **Enio Persion**'s 50th wedding anniversary. Now on their second honeymoon, Enio and Loretta called on us at Westport, Maine (where we spend six month of each year). We went by boat to Boothbay Harbor, and on the way back stopped at Juniper Point and saw **Bob Leadbetter** and the new wharf he has just built. He and the wharf look great."

Eliot "Ducky" Graham and I were fraternity brothers and lived in the same house during our college years. His wife's and his deaths (reported last issue) came as a great shock to all of us, especially those who knew him well. Here is further information, taken from a news clipping sent by the Alumni Association: "Eliot and Josephine (Jacoby) Graham both died August 1 after an automobile accident. They were returning to Leisure World, a retirement community in California, when the accident occurred. Mr. and Mrs. Graham were married in 1940. Mrs. Graham was born in Middletown, N.Y., September 22, 1906. She was a graduate of Middletown High school in Middletown, N.Y. Eliot Graham was born in Canajoharie, N.Y., on August 28, 1908, son of Edward and Florence (Seeber) Graham. Mr. Graham retired from the U.S. Army with the rank of colonel. He worked as a civilian employee for the Army, and his last employment was civil service. He retired about 20 years ago." . . . Other deaths reported by the Alumni Association are **Michael Kundrath**, **John W. Carleton** and **Mario Caputo**. According to newspaper clippings, **Michael Kundrath** was born in Bridgeport, Conn., and lived in Fairfield. After graduation, he joined the firm of Stephen Kundrath Insurance and Real Estate Agency, of which he was president until retirement 12 years ago. Another clipping adds that he belonged to the M.I.T. Alumni Club of Fairfield County, the Spisok Fayerweather Yacht Club, the American Association of Retired Persons of Fairfield and the William Pitt Association. . . . No further information was received concerning **John Carleton.** . . . The *Boston Globe* said that **Mario Vincent Caputo** went to Washington in 1934 as an architect in the Supervising Architect's Office and stayed there until 1947. By the time he returned to Boston to open his private architectural practice, he had helped design many government buildings, and it was his design that had been chosen for the General Accounting Office, one of the larger buildings in the nation's capital. He worked on the design of the War Department Building, the National Archives Building, and the San Francisco Mint, and while in Washington he was chosen to work in the White House with the Architect for the White House. Mario was a member emeritus of the American Institute of Architects and the Boston Society of Architects. He died after suffering a heart attack. Our sincere condolences to all of their survivors.—**Edwin S. Worden**, Secretary, P.O. Box 1241, Mount Dora, FL 32757; **Ben W. Steverman**, Assistant Secretary, 2 Pawtucket Rd., Plymouth, MA 02360; **John R. Swanton**, Assistant Secretary, 27 George St., Newton, MA 02158

32

Kenneth W. Smith writes that he is active in Kiwanis Club, golf, and photography. Betty and he are at Indian Rocks Beach, Fla., from November through April. Time marches on but there are lots of fine memories of days at Tech and, especially, Phi Sigma Kappa. . . . **Richard A. Lobban** and wife Dorothy had an interesting visit with their son Rick and his family in Cairo, Egypt. Rick is on loan at the American University to create a research program on urbanization. Richard observes that America's 300 years and Egypt's 3,000 years make quite a contrast. This fall the Smiths will celebrate their 50th wedding anniversary with children and grandchildren (15 in all) at the Chateau Frontenac in Quebec where they went on their honeymoon. Richard still enjoys retirement in New Hampshire.

Al O'Neil, Don Brookfield, William Pearce, and **John Brown** represented our class at the Alumni Fund Telethon in October. John spoke with **Charles McCormack,** who is now retired from DuPont in Wilmington, Del. His six children keep him busy. . . . John also reports that **Bernard Markstein** is still active in business. He likes

to take trips with his grandson. . . . **Bill Pearce** is moving from Sharon, Mass. to Mattapoisett, Mass. . . . **Wendell Bearce** attended an M.I.T. seminar on the benign use of coal.

Mrs. **Edwyn A. Eddy** writes that Edwyn died on September 11, 1983. He had been sick a long time with mesothelioxia, and that terrible disease finally caught up with him. He is at peace. . . . **Dominic A. Perry,** 75, died following a lengthy illness on July 7, 1983. He was an army veteran of World War II. He had spent his career in the construction, survey and design field. He formed the State Highway Department in Meriden, Conn., in 1941, and acted as senior engineering aide. He is survived by his wife, three children and three grandchildren.

Alfred Berghall, 77, died on May 31, 1983. He worked as a consultant to aircraft manufacturing companies for many years. He is credited with developing the mathematical tool called the "Learning Curve." His books were translated into Chinese, German, and Russian. The Berghalls hosted a week-long arts and crafts show at their residence (which he built himself). In his later years he revived his interest in painting. Perhaps his most outstanding one was entitled "Pandoric Thermonuclear Genie" painted in the fifties before opposition to nuclear proliferation was popular. He is survived by his wife Jo and brother Robin.—**Melvin Castleman,** Secretary, 163 Beach Bluff Ave., Swampscott, MA 01907

33

The notice to the effect that your acting secretary has current addresses for classmates did bring a request from **Bob Dillon** and his wife, Alice, who are living in LaMarque, Tex. After a career with Union Carbide, he wanted to get in touch with **Fred Kressman,** the pine-stump product man. Bob is national vice-president of the Carbide Retirement Service Corps which seeks opportunities for these folk to use their technical and managerial skills. For two vacations they cruised on European rivers. Like so many of us he doesn't have enough time now that he has stopped working. . . . If you would like an address, send me word about yourself and I will come right back to you.

We '33rs do get around. Since the last notes we have pretty postcards from Charlee and **Dick Fossett,** our vice-president, who resumed their hiking in the Tirol even if they have slowed down some. The scenery is just as breathtaking as ever. . . . The **Mal Mayers** sent us a card of a Dutch windmill in South Africa—the Hollanders settled that part of the world, you'll remember. Let these be reminders to you that all of us like to hear from you. If you are bashful about your own activities, tell us about a classmate.

Word comes from **Warren Henderson** that the **George Stolls** went "bare boat" sailing around the British Virgin Islands before our reunion and liked it so much that they are planning a repeat for 1984. George, thanks for a good job of "treasuring" through the years, climaxing with our 50th! . . . Send us a letter or a card while you are away this spring. George writes that there are a number of our group in Florida. Drop him or me a note of your Florida address.

Chuck Fulkerson and family went to Palo Alto for Christmas. . . . **Niazi Mustafa** went home to Cairo and hasn't been heard of since. **Dick Morse,** you are our source of information; send us some about Musty. Or better, Musty, you drop us a note. We know you had a son at M.I.T. Does anyone have a grandchild at Tech yet?

Spring has come and our New England friends followed the birds south. **Dick Morse** was to send us a note from Antarctica this winter—it hasn't come. When we were in Cambridge one of our "cute" fraternity pledges sent himself a card care of Byrd Antarctic Expedition. It came back "unknown at this address" . . . a unique philatelic item.

Do you want to see how you changed in a quarter century? You remember the 25th anniversary issue of *Technique* that **Ed Goodridge** put together for us . . . look in your memorabilia. I did and I expect there are a lot of us like me who don't believe that we ever had so much hair, and without a trace of gray either! It is good to know that we are making it so well after all these years! . . . If you are coming down or up I-85 or I-95, give us a call to see if we are home, and then drop in. We are usually at home and have a guest suite . . . and we don't do our own cooking anymore!

Since our last such report, we have news from the Alumni Office of these deaths among our classmates: **Bretton Perry,** construction; **Robert M. Love,** founder an developer of Allegheny Airlines; **Horace Wayne Taul,** a civil engineer who was living in California; and **Outerbridge Horssey,** who joined the Foreign Service in 1938 and served as U.S. ambassador to Czechoslovakia.—**Beaumert Whitton,** Acting Secretary, Cottage 112, Sharon Towers, 5150 Sharon Rd., Charlotte, NC

34 50th Reunion

We have an Alumni Fund note from **John M. Thompson,** who writes, "I have closed my downtown office for the practice of architecture. Have a small office here at home. I miss my work and activity very much. Have some small work here at home. My wife keeps me on the go all the time. My advice: Do not retire as long as you can hold a pencil in your hand." As you've read before, my own feelings do not jibe with John's. Working as an individual practicioner may bring certain satisfactions that keep work enjoyable, but I have never regretted my early retirement. As for keeping busy, this month's calendar had only six days that didn't call for being somewhere and doing something. Most importantly, Jane and I got to do things and go places while we were "we" and not just "me." So much for my soap box!

Paul Wing has been made an honorary member (their highest membership grade) by the Instrument Society of America. This recognizes his continuous contributions to the application of control valves in a 48-year career in the instrumentation field. From 1935 to 1941 he worked for Universal Oil Products Co. and then in 1942 began 38 years with the Masoneilon Division of McGraw Edison. Over the years, Paul served as manager of engineering, product planning and marketing, and worldwide engineering manager. He was vice-president for engineering at the time of his retirement in 1980, but he has continued general consulting for the firm. Of equal interest to us is one of Paul's hobbies, stereoscopic photography. I'm not sure all of his work is confined to bird life, but his setup at home has bird feeders strategically sited to give the best photographic results. His work has brought him international recognition, and he is currently president of the International Stereoscopic Union. In this capacity he presided last fall at a five-day conference on this aspect of photography in Buxton, England. As part of the 50th Reunion entertainment, Paul is going to show some of his work—probably Wednesday night for the early arrivals.

Speaking of the Reunion, it looks like it will be a "barn burner." The committee met recently and settled virtually all the final details for the festivities next June. By the time you read this you will probably have received our final full mailing. Your response has been great, but when any fence-sitters read the program we have lined up, I hope they will decide to come join the party.

This issue will blanket my proposed winter jauntings. I'm spending the first week in February in Sint Maarten, West Indies, with a three-day jump over to Saba. Then I'm taking the Quarter Century Club's 22-day trip to India—the end of February and the first half of March. It was the spread between Sri Lanka and Nepal, and points in between, that got me.—**Robert M. Franklin,** Secretary, P.O. Box 1147, 620 Satucket Rd., Brewster, MA 02631; **George G. Bull,** Assistant Secretary, 4601 N. Park Ave., Apt. 711, Chevy Chase, MD 20015

35

Here's the final report on the 23rd Annual Class Golf: **Sam Brown** won his match with **Frank Hatch** to take the Grey Consolation Flight and was to play **Chet Bond** in the semi-finals. Murphy's law stepped in and tripped Sam at the Newark Airport as he and Natalie were flying south for the winter, and he injured his leg so badly that he had to default his match with Chet. I called him in late October and he was slowly recovering, but no golf. **Bill Bates** made the finals by winning from **Dick Shaw.** In the finals Bill came through with another fine game to win over defending champion Chet in a very close match. This is not the first time Bill has won the championship; in 1977 he retired the cup by winning it three times during the previous 11 years. We are now on our third cup, with no repeaters so far! The winner gets his name engraved on the cup and keeps it for a year.

The only other news I have is of the death of **William B. Lauder,** in Leon, Mexico, on March 3, 1983. Bill was in Course V; at the time of our 25th Reunion he lived in Syracuse, N.Y. According to the report we received, he leaves no known survivors. If anyone has more information, I would surely appreciate it.—**Alllan Q. Mowatt,** Secretary, 39 Congress St., Apt. 5, Nashua, N.H. 03062

36

There were 20 of us—class members, spouses, and two daughters—for a happy reunion lunch and supper on October 29. I'll tell you more of that and other pleasant events after I have reported on the obituaries: Word comes of the death sometime in 1980 of **Morril Spaulding.** His widow survives; no other information is available. Her address is 4341 Montgomery Ave., Bethesda, MD 20814. . . . **John Kleinhans** died on September 13. No survivors were listed in the newsclipping. He started with us but transferred to Lehigh, where he received his degree. He was with the J.T. Baker Chemical Co. in new Jersey until he joined General Tire in Akron in 1953. In 1962 he was named vice-president of chemical operations in the chemical plastics division and in 1969 he became a special assistant to the president of that division. He retired in 1975. . . . **John L. Speirs,** who was retired from Brookhaven National Laboratory, died on October 12 of a heart attack. He received his Ph.D. from Michigan State University and had been at Brookhaven since 1954. He is survived by a sister.

Bernard Vonnegut has been honored by the Board of Trustees of the State University of New York by being named a distinguished professor. This is the highest professional rank in the system. His feet may be on the ground but his head is in the clouds, literally. He pioneered in research on cloud seeding while at General Electric from 1945 to 1952. At Arthur D. Little, Inc., he studied thunderstorm electrification, and his interest in electrically charged clouds has continued at State University of New York Albany. . . . Once again, **Laddie Reday** has been trekking in a far away place—this time in the Caucasus Mountains in Soviet Georgia. . . . **Roman Ortynsky** writes from Peachtree City, Ga., in between attending a Georgia Horticultural Society meeting and a local section meeting of the American Chemical Society, that he obtained an old *Technique* through the efforts of Warren Seavers of the M.I.T. Museum and has had a chance to revive memories of long-ago happenings during his years at the Institute. He's getting primed for our 50th Reunion.

As to the mini-reunion: attending were Pauline and **Ken Arnold,** Mary and **Fred Assmann,** Kitty and **Herb Borden,** Vivienne and **Eli Grossman,** Rilla and **Walt MacAdam,** Virginia and **Augie**

Mackro, Marian and **Jim Patterson** and daughter Marcia, Lillian and **Larry Peterson**, **Dana Devereux**, and your secretary and daughter Martha. After lunch we shared information on classmates, Walt Macadam brought us up to date on the radiation question, and a lively discussion on investments topped off the session, giving us time for walks both easy and strenuous. We're making plans for next year and will welcome inquiries from anyone interested in attending. Mary Assmann has agreed to coordinate the affair again. . . . Following the party I had a note from **Jim Patterson** in response to a comment about him in the notes some time back. He officially retired from Union Carbide in December, 1981, after 45 and a half years. He formed a small company, with Carbide as his first client, and now has additional work but can find time for hunting and travel. He continues to serve on the board of directors of the Westchester Association for Retarded Citizens. It's fun to keep busy, as I well know.—**Alice H. Kimball**, Secretary, P.O. Box 31, West Hartland, CT 06091

37

Edwin H. Olmstead, 326 Pine Rd., Mt. Holly Springs, PA 17065, now retired, became interested in the Civil War when he moved to Gettysburg, Pa. He is a fellow of the U.S. Army Military History Institute. Edwin co-authored *Field Artillery Weapons of the Civil War* recently published by the University of Delaware Press. . . . **Robert H. Thorson**, 66 Swan Rd., Winchester, MA 01890, had a heart attack on May 1, 1983. He was hospitalized for two weeks and convalesced at home another seven weeks. He returned to work gradually, starting with half days. Bob is now feeling fine. Rose, Bob's wife, underwent two operations on her back in 1982 but is now recovered. Both of them are enjoying curling and golfing. Bob is still active on the board of directors at the Lawrence Memorial Hospital as vice-president in charge of development.

Dr. **Bernard Ross**, 230 Entrada Ave., Port St. Lucie, FL 33452, informs us of his new book, *IMT, The Fundamental pathway to Better Health, The Case for Individualized Mini-Dose Therapy*, will be released in late February or early March. It is "the ultimate blend of old fashioned sympathy and modern medical technology." The publisher, Mariner Press of Tampa, Fla., has arranged for Bernie to do a ten-city promotional book tour following publication. Bernie was appointed chief of medicine of the new 150-bed Port St. Lucie Hospital. The hospital's Bernard Ross Library is named in his honor. Bernie's wife is still managing his office and is also jointly managing a nearby boutique with her daughter.—**Lester M. Klashman**, Assistant Secretary, 289 Elm St., Apt. 71, Medford, MA 02155; **Robert H. Thorson**, Secretary, 506 Riverside Ave., Medford, MA 02155

38

The 50th Reunion committee held two meetings—one last fall, hosted by **Norm Leventhal** at the new Meridian Hotel in Boston, and one in early winter at M.I.T. **Ed Hadley** is chairman, and he urges your support for our 50th Reunion class gift.

Barney Oldfeld, though living on Cape Cod, is still working full-time as a vice-president of Medequip, Inc., a supplier of computer-based systems for medicine. In his spare time he is writing a novel on the evolution of high technology. I guess you could call it science-fiction. His wife, Norma, retired last fall as director of member services at Cape Cod Museum of Natural History, and then two weeks later accepted a job as administrator of the Museum's fund program.

One death to report: **Willard Beye** passed away last September in San Diego.—**Armand L. Bruneau, Jr.**, Secretary, 663 Riverview, Chatham, MA 02633

39

Dominic Donatello was complimented again when the magazine *Alaska Business and Industry* featured his picture in color on its front cover. A 16-page story, "From Tallow to T-Bone;" described his latest enterprise—another Alaska "first"—a two million-dollar livestock slaughter and processing plant. Dom: come to reunion, and bring steaks! . . . **Harold Pope** was honored by Sanders Associates which established the Harold W. Pope Technical Park. Included in the citation was: "Mr. Pope dedicated his career to the unending pursuit of technical excellence, imaginative management and techniques, and personal development of employees.". . . **Robert Pratt,** having retired from United Technologies Corp., is active on Cape Cod where he was reelected president of the M.I.T. Club of Cape Cod. Bob is hoping to lead 100 percent of all Cape Cod classmates to the reunion June 4.

Seymour Sheinkopf reports that the reunion committee met and started work. Because 147 attended our last reunion, the committee expects many will be arriving this time via Boston Airport. To make a warm welcome for these flying '39ers, a hospitality suite has been arranged at the Airport Hilton. There they can congregate comfortably until the afternoon (June 4) when a bus will take them directly to Martha's Vineyard. Classmates not arriving by air can go either directly to the reunion site or ask the committee to arrange for their pickup at M.I.T. or in groups at enroute locations. At the reunion site there will be a clambake and banquet. Also music by Aaron White's "Serenader Smoothies and Downtown Jazz Band." Departure from Martha's Vineyard will be on Thursday, in time to permit attending the traditional cocktail hour at M.I.T., followed by Boston Pops in the evening, and then the full-day's program on campus Friday.

The reunion committee includes: **Bob Casselman, Joe Dana, Ernie Kaswell, Marty Lindberg, Manning Morrill, Bob Pratt, Fred Schaller, Hal Seykota, Seymour Sheinkopf,** and **Aaron White**.

The committee will be assisted by area members who are **Jim Barton, George Beesely, Pete Bernays, Harold Muckley, Irv Peskoe, Oz Stewart, Charles Wang,** and **Bill Wingard**.

Each classmate will receive a mailing outlining details. Let's respond promptly about our reservations and smooth the work these 18 people will be doing on our behalf.—**Hal Seykota**, Secretary, 1603 Calle de Primra, La Jolla, CA 92037

40

W. Kenneth Davis, independent consultant affiliated with Bechtel Power Corp., San Francisco, Calif., and former deputy secretary of the U.S. Department of Energy, was one of four recipients of the 1983 Founders Award of the American Institute of Chemical Engineers (AIChE). The award was presented to Kenneth at an honors luncheon on October 31, in Washington, D.C., during the five-day AIChE annual meeting. He was selected for his accomplishments in the field of nuclear engineering and development of alternative energy sources. . . . **Dudley Follansbee** retired several years ago to Maine where the cruising and skiing are the best, or so he says. Most of his time is spent in community activities and in assisting his son with his marine business, which involved importing sailboat equipment for the U.S. market.

A note from our former class secretary, **Al Guttag**, reports that he is still with Cushman, Darby, and Cushman and running 2,300 to 2,500 miles each year! Last June he went to Europe to the AIPPI meeting in Paris in celebration of the 100th anniversary of the Basic International Patent Convention. Also visited throughout the continent. . . . **Kingsbury T. Jackson** has left the Los Angeles Unified School District, where he has been the contract supervisor for the past several years, to start a consulting business that will furnish assistance to California school districts in school business contract matters.

Some 500 friends and colleagues at AT&T Bell Laboratories gave **Stewart E. Miller** a technical symposium as his retirement gift last September . . . quite different from the old gold watch traditional gesture. Stu retired after 43 years of telecommunications research at Bell Laboratories. He had been director of the Guided Wave Research Laboratory since 1958, dealing, among other things, with transmission of information by light.

S. E. Miller, '40

"He was the first to take on the challenge of making lightwaves a viable way of communicating," Arno Penzias, vice-president of research, told the audience. "How well he and his colleagues met that challenge is evident in the present growth of lightwave technology throughout the world." Stu holds 73 patents and is the author of 38 published articles and co-editor of a book, *Optical Fiber Communications*." He has received the W.R.G. Baker Prize and Morris N. Liebmann Award from the IEEE, the Naval Ordnance Development Award, and the Franklin Institute Stuart Ballantine Medal. Stu is also a fellow of the Optical Society of America, the American Association for the Advancement of Science, and the Institute of Electrical and Electronic Engineers; he is also a member of Eta Kappa Nu and Tau Beta Pi engineering honor societies.

A news clipping indicates that Colonel **George R. Weinbrenner**, U.S. Air Force, retired, received a Presidential Citation from the Air Force Association last September. Only ten have been awarded among 200,000 members. George was also named "Air Force Man of the Year" by the Texas Air Force Association.

An October news release reports that the Caucus of New England State Legislatures announced its selection of Representative **Arnold Wight** as "Legislator of the Year" from the state of New Hampshire. Arnie was praised for his work in designing and pursuing a satisfactory compact for dealing with disposal of low level radioactive waste in the northeastern United States. In addition, Arnie and Professor Frank Iddings of Louisiana State University held a public symposium in Concord, N.H., in November, on "Energy and Technology: Who Can the Public Trust."

While vacationing in Florida recently, your class secretary and wife, Sue, visited with **Doug Eckhardt** and wife, Lois, who are living in Fort Meyers Beach, Fla. Doug is enjoying his retirement, which includes cruising in the Florida waters, as well as carrying on stock brokerage activities.

I have some sad news to report, as obtained from mail return information to M.I.T. **Oliver K. Smith** of Pacific Palisades, CA 90272 died on August 11, 1983. . . . **Leo W. Rainard** died on September 20, 1983. His address was 107 Lighthouse Road, Edgewood Hills, Wilmington, DE 19809. No other information was available.

Our class treasurer, **Ed Bernard**, reports a 39 percent initial return on invoices for yearly dues mailed to the undergraduate degree members of the class. Let's keep those checks coming so that our next reunion will be a super affair.—**Donald R. Erb**, Secretary, 10 Sherbrooke, Dr., Dover, MA 02030, (617) 785-0540

42

A note from **Steve Stephanou** tells us that he has published his second book, *The Systems Approach to Societal Problems*, which can be obtained from Daniels Spencer Publishers in Malibu, Calif. . . . **Bob Howard**, who's currently with the IBM General Technology Division in Essex Junction, Vt., wrote a very interesting article about "a new package-related failure mechanism for leadless chipped carriers." Bob, who received his S.B. and Sc.D. degrees in metallurgy, was a professor of metallurgy at the University of Kansas, at Wichita State University, and at the University of Missouri in Kansas City for 12 years prior to joining IBM in 1968. Although we mentioned **Bill Den-**

W. Denhard, '42

hard's retirement in the last issue, a very interesting story of Bill's 35-year service appeared in *The Charles Stark Draper Laboratory Notes* for August. It mentions that Bill's "mild disposition" belies the stories of his encounters with Doc Draper. "Once he smashed the glassed top of Doc's table with his fist as he banged it for emphasis!" Again, our congratulations to Bill on a very outstanding and unusual career and best wishes for his happiness and success in retirement, especially since he can now spend even more time counting our money as class treasurer.

Jean and I spent a very pleasant evening with Fran and **Bill Strong** in Houston, Tex. in November. Bill and Fran have lived in Seabrook, a suburb of Houston not far from the NASA Space Center, since 1962. They built a very beautiful house which backs up on one of the local lakes. You may recall that Bill is quite a sailor and is past commodore of the Houston Yacht Club. I was amazed to find out that the Houston Yacht Club has 700 family members and is the biggest yacht club in the area. **Bob Benware** lives a few blocks from the Strongs but, unfortunately, was out of town on a business trip, so we did not see them. Bill arranged a trip through the NASA facility by getting in touch with Hank Bowes, '44, who is now with Lockheed located at the space center.

On a personal note, your secretary was recently re-elected to another two-year term as associate treasurer of The Union of American Hebrew Congregations which is the Federation of about 780 Reform Jewish Congregations in the United States and Canada.

As usual, we surely could use some more news. By the time you read these notes it will already be spring. But since I am dictating them during the middle week of November, best wishes for a wonderful Thanksgiving, a merry Christmas, and a happy and healthy New Year. **Ken Rose**, Secretary, 191 Albermarle Rd., White Plains, NY 10605

43

This month's mail has provided news to the extent of one obituary notice. **Howard Scott**, of New Braintree, Mass., died October 12 at the age of 63. Howard was a submarine officer in World War II, then joined Bird-Johnson Co. of Walpole as a salesman. He rose through the ranks to become the company's chairman and CEO, retiring in 1982. We send our sympathies to his wife Margaret and to the other members of his family.

Having no other news, I am finally reduced to a brief report of my own activities. Engineering consulting remains very slow, but the oil and gas royalties business is satisfactory. The University of Oklahoma's football standing has dropped so low that ardent fans are hoping for an invitation to the Liberty Bowl. It was only 34 years ago that O.U. astounded eastern sportswriters by invading New England to shred Boston College. When all else fails, I can contemplate the activities of a quilting wife, a daughter at Mount Holyoke, and grandchildren in Seattle and Sealy, Tex. This is deadly. Please send news.—**Bob Rorschach**, Secretary, 2544 S. Norfolk, Tulsa, OK 74114

44 40th Reunion

By now you have received the second mailing regarding our 40th reunion to be held in Newport, R.I. and Cambridge, Mass. on June 4-10. Your committee continues to work hard to make this the best reunion ever.

We appreciate the time **Robert M. Isaacs** took to add a note to his alumni fund envelope. Bob writes, "After many years of working throughout the U.S. and Canada, finally succeeded in getting moved to Tucson, where I plan to work another 18 months before retiring in the part of the country that Kathleen and I love."

A clipping from the *Bridgeport* (Conn.) *Sunday Post* notes that **Albert Madwed** was to lead a seminar at the Bridgeport Engineering Institute's Continuing Education Division to preview a series of certificate programs centered around the "Introduction of Robotics into the Contemporary Factory." Madwed is president of A. Madwed Co., Easton, and vice-president of Madwed Corp., Bridgeport. He has studied the growth of the robotics industry and its applications for the past 20 years and is recognized by the Robotics International of the Society of Manufacturing Engineers as a certified engineer in the field of robotics.

Dorothy (Mrs. **John C. Conroy**) reports that her husband died several years ago. Our belated condolences go to her and her family.

The skiing has been excellent in parts of the country this winter, while others have reveled in the warm sunny climates. See you at the reunion.—**Melissa Teixeira**, Secretary, 92 Webster Park, West Newton, MA 02165

46

Two tiny items managed to trickle through to me this month. Received notice of the passing of **Stewart Grandfield**, of Santa Barbara, after his "losing battle with cancer." . . . The other was a "thoughty" post card from **Larry Body**, taking a short vacation at a fabulous resort in San Diego. While there, who came through on his way to a vacation in Hawaii (Maui Wowie?) but **Don Burke** and his wife, Pat. (Sigh). Got any hot tips on municipal bonds, Don? Turns out, Denver's rated AAA+, I hear.

Thumbing through the yearbook and seeing scores of familiar faces I haven't mentioned previously, I thought I'd take a shot at introducing some of them, starting at the top. I'm using a two-year-old roster, so the info may be dated. . . . **Dick Adler**, Course XIII, must have stuck it out because he's listed as working at the Avondale Shipyards in New Orleans, where he also lives. . . . **George Ahmuty** is president of Allis and George Co. in Saugatuck, Conn. and lives in Westport. Must "have it made." . . . **Jack Aiten**, old Philly friend, got out of aerospace and into his own CPA business in Philadelphia. He's still living in his "birthplace" out in Chestnut Hill. If I take back what I said about Ron Reagan, will you forgive me, Jack? . . . **Howard Auerswald** listed as president of Tubed Products in Easthampton, Mass. It was nice to see this distinguished, gentle man at the 35th. . . . **Walt Backofen**, who somehow got through as a metallurgist, must have his own business in Lebanon . . .New Hampshire, that is. Had me scared for a minute.

Th-th-th-that's all, folks. "Have a good one."—**Jim Ray**, 2520 S. Ivanhoe Pl., Denver, CO 80222

48

Lou Kreek was chairman of the committee that planned and presented the 1983 National Alumni Conference. The conference brings together alumni volunteers working to support M.I.T. Some volunteers are officers of clubs, classes, and courses. Other volunteers are chairpersons of Alumni Fund groups, Educational Council areas and committees of the Alumni Association. Also included are all the alumni working on these projects. Lou's committee planned several excellent workshops enabling attendees to interact with one another and with the Alumni Association staff. In addition, at the conference, presentations by M.I.T. president Paul Gray and by several undergraduates informed us of current activities and of research opportunities. **Jack Page** succeeded Lou as chairman of the committee to plan the 1984 conference in Toronto and Dallas. Congratulations to Lou on a successful conference, and our best wishes to Jack as he undertakes his new responsibilities.

George Clifford, president of our class, **Bob Sandman,** and **Leon LaFreniere** arranged a '48 mini-reunion on Saturday evening after the National Alumni Conference. Attending were George and his wife Ginny, Nan and **Bob Bliss,** Ann and **Harry Jones,** Joan and **Al Seville,** Imogene and **Jack Page,** Tel and **Bob Sandman,** Jean and **Milton Slade,** and yours truly.

Imogene and Jack arrived at the conference after attending their other son's wedding in Chicago. This son is the controller at a large architectural firm there. They also have a married daughter with two children who live in Wilmette. Their youngest son is married and lives in Dallas. Imogene and Jack recently spent several days on the Maine coast which included a trip to a charming restaurant on Cranberry Island. While there Imogene visited a yacht club whose burgee she had acquired, which completed her record of visiting every yacht club for which she has a burgee.

Carol Accardo is president of Epsilon Laboratories, and **John Dulchinos** is director of Engineering there. The company studies auroral phenomena and solar eclipses. They also measure submicron particles in the upper atmosphere and in space and photographically measure single particles. In addition they manufacture particle counters for atmospheric research and are developing reliable synchronizing controllers for a simple camera that would photograph every user of an automatic bank teller. Their equipment will control exposure and the film drive. Their work has taken Carl to the arctic, and his equipment was taken on the space shuttle.

Charlotte Fraser writes, "Once a student always a student." She is still adding to her collection of academic degrees, the latest being a Ph.D. in higher education with specialization in academic libraries. . . . **Bob Bliss** was elected to the board of trustees of the New England Historic Genealogical Society. The society is a nonprofit institution founded in 1845 for the purposes of collecting, studying, and preserving New England family and local history. As the oldest and largest organization of its kind, the society has 6,000 members, maintains a research library of 300,000 items, regularly publishes books and a quarterly journal, and sponsors educational programs both in Boston and across the country. Bob and Nan live in Georges Mills, N.H. Bob has been a member of the M.I.T. team to raise capital to support M.I.T. He was appointed the midwest district officer for the M.I.T. Leadership Campaign. Prior to joining M.I.T.'s capital drives, Bob spent many years at USM Corp. He was divisional sales manager, general manager, director of the mechanical laboratory, and planning director.

Francis Crowley is president of Natgun Corp., a company he formed to construct concrete tanks which hold drinking and waste water for towns and cities. Francis has patented his system for on-site construction of pre-cast concrete tanks that hold 100,000 to 20 million gallons of water. He has licensed competitors to use his system. Frank employees key personnel, and they hire local labor for jobs throughout the country.

Frank Durgin runs the Wright Brothers Wind tunnel at M.I.T. Despite the great sophistication of this equipment, it is not uncommon for Frank to spend his evenings with a wrench in his hand in order to make the wind tunnel do what he wants it to do. . . . **Bill Schmidt** is the third generation of his family to operate a CocaCola bottling firm which was founded in Kentucky in 1901. Two of his sons are fourth generation employees. Bill has 195 employees in Elizabethtown (population, 15,000). The firm has the biggest memorabilia exhibit of CocaCola products. During the summer an average of 400 visit the exhibit daily.

Bob Rowe spent 30 years in construction in Weston, N.Y. At the time of his early retirement, construction projects ran about $80 million per year, and Bob was vice-president and chief engineer. He started an office in Charlestown, S.C., which he built up to $45 million per year. Retired again, he is spending four days per week as a consultant on shopping centers and other projects. . . . **Henry Gilbert** of Juno Beach, Fla. is at the Norton Gallery School of Art. His sculptures of stone and wood are both realistic and semi-abstract with some philosophic themes. . . . **Tom Jabine** is chairing the Committee on Scientific Freedom and Human Rights of the American Statistical Association.—**Marty Billett,** Secretary, 16 Greenwood Ave., Barrington, RI 01806

49 35th Reunion

Received a phone call from Tech the other evening (Alumni Fund Telethon)—**Andy Bigus** and **Stan Margolin** were soliciting. It's nice to hear from someone you know. Incidentally, don't forget, we still have the Class of 1949 Visiting Professorship Fund, and it is still growing and still needs your help. So, besides planning for our 35th on campus and in Bermuda, please plan a little extra for our own professorship.

I had the unexpected pleasure recently of meeting with **Frank Dineen** on a business call and he was a most understanding customer—he has been using my equipment for many years. Frank has spent 24 years with National Starch Co. and is now an engineering manager in the New Jersey corporate headquarters. Frank is still swimming a good deal. His daughter Karen is the second-place champion board-sailor in the country.

Jack Littlefield sent a most welcome letter bringing me up-to-date on the **J.B. Bobby** family. J.B. is in his 18th year as a manufacturer's representative. They have a summer home in Marblehead when they want to get away from the toils and tribulations of Greenwich, Conn. Bobby teaches kindergarden, and their son Bart is about to graduate from Stanford Business School in June. (I hope this does not interfere with our 35th, Jack).

Charles O. Miller is president and principal consultant of System Safety, Inc. of McLean, Vir. In 1983 he received two prestigious awards: the Lederer Award from the International Society of Air Safety Investigators and the Professional Development Award from the System Safety Society. Charles has spent 30 years in aerospace safety activities. His aeronautical engineering degree has been well-used!

Roger J. Moore sent a note telling us that he is property manager for Europe at AFIA Worldwide Insurance in Brussels, Belgium. He sends an invitation to all classmates coming his way. Since he enjoys living in Europe, he should make a good guide. I wish I had had a better guide through Belgium 39 years ago.

Nathan O. Sokal has a most interesting sideline to his vocation. In 1965 he founded the Boston-based Design Automation, Inc., an electronics consulting company specializing in design and problem-solving for equipment manufacturers. Nat's engineering staff includes Hungarian and Israeli engineers who take a one-year sabattical from their native jobs to work with Nat. Nat finds them capable and up-to-date on technical matters, and they return home with a favorable first hand impression of the United States.

By roundabout ways, we heard about **Joseph A. Stern**. He is president of Bionetics Corp. and lives with his wife Phyllis in Hampton, Va. We understand that Bionetics has many offices around the country but do not know what Bionetics does. . . . **Bernard Steinberg** published a new book in October 1983 entitled, *Microwave Imaging With Large Antenna Arrays: The Radio Camera Principles and Practice*. The book describes Bernard's last ten years of research at the Valley Forge Research Center. . . . **James Verras** is a management consultant and has been engaged as deputy to the director of the World Industry Conference of Environmental Management to be held in Europe in late 1984. . . . See you around the campus . . . for our 35th.—**Paul E. Weamer**, Secretary, 331 Ridge Meadow Dr., Chesterfield, MO 63017

51

George Hand reports he belongs to Quarter Century Club after over 25 years with IBM. He is now in the program office there working on the sonar system of the Trident submarine. His hobby is carpentry. . . . **Harold Siegel** is completing his 17th year as vice-president and general counsel for Radiation Systems, Inc. of Sterling, Va. His wife Valerie is in her final year of law school at the University of Baltimore. . . . **William F. Steagall, Sr.** retired from System Development Corp. in April 1981 and is now consulting on major defense proposals, sailing, and racing his *Lotus 23* in vintage events. . . . **George Field** stepped down in January 1983 as the director of the Harvard-Smithsonian Center for Astrophysics in Cambridge, and will continue at Harvard as Robert Wheeler Willson Professor of Applied Astronomy and at the Smithsonian Astrophysical Observatory as senior physicist. He was succeeded as director of the CFA by Irvin Shapiro, formerly professor of physics at M.I.T. **Bernard Rothzeid**'s firm, Rothzeid, Kaiserman, Thomson, and Bee, P.C., recently received the Albert S. Bard award for merit in architecture and urban design from the City Club of New York for the City Center Restoration and the 1983 Grand Award from the National Association of Home Builders and the Lumen Award Citation from the New York Illuminating Engineering Society for their West Coast apartments. . . . **David I. Caplan** reports that he and his wife Elinor have moved to the San Francisco area after spending their entire life on the East Coast. Dave is now senior vice-presiident, technical operations at Fortune Systems, a manufacturer of small computers for office automation. All four of their children are in the Boston area—two out of college and two still in college. . . . We regret to report the death of **Matthew C.C. Chisholm, Jr.** and **Arthur H. Schein**.—**Gregor J. Gentleman**, Secretary, 600 Holcomb, Suite 1, Des Moines, IA 50313

52

Two classmates send news of moving ahead in their careers. **Clifford Morse** fulfilled an ambition by opening his own architectural office last June, in partnership with a Roman architect, to form an international firm called Morse Bracci-Devoti. He says the firm does architecture, planning, interior design, and renovation, and is housed in a stone castle in Berkeley, Calif. . . . **Edwin Porter** last summer became head of the Air Force Programs Department of the Charles Stark Draper Laboratory. As it is my professional habit to look for symmetry, I must remark that Cliff grew up near Boston and now works in the San Francisco Bay area, while Ed came from the Bay area and now works near Boston.

Two classmates died last summer. **Herbert F. Head,** of Los Altos, Calif., died August 23, 1983. For the last 14 years he worked as a naval architect for Earl and Wright of San Francisco. Prior to that he was employed by Brown and Root in Houston. He is survived by his wife Josephine, four daughters (two married and two at home), and six grandchildren. . . . **George L. Roehr,** of Lincoln, Mass., died September 13, 1983. He was the founder and president of Roehr Tool Corp. of Waltham, a manufacturer of plastics molding equipment. A native of Cracow, Poland, he came to this country at age 10. He is survived by his wife Marcia, three daughters, three brothers, and a sister.—**Richard F. Lacey,** Secretary, 2340 Cowper St., Palo Alto, CA 94301

53

Although the flow of information from classmates has slackened a bit, I'm hopeful that we will soon begin to see results from our requests in recent columns.

Joe Cahn, assistant class secretary for points west of the Rockies, has sent some personal information. Joe, an attorney, is a partner in the law firm of Greenberg, Glusker, Fields, Claman and Machtinger in Century City, a Los Angeles exurb. Joe is a litigator; he handles cases involving real estate, investment frauds and unfair competition. Joe has been married to Audrey since two years after graduation, and they have four children (all pretty much grown up). . . . **Fred Van Sicklen** dropped us a brief note saying he was sorry he missed the reunion, and he sends his regards to all. He also writes that he is chairman of the board of Forsythe Industries, Ltd., in Rancho Santa Fe, Calif., a privately held company with $85 million in annual sales. Fred didn't say how good the profit margin was or whether they had any plans to go public.

From our 30th Reunion survey, we find that 35 percent of the class own their own businesses and work an average of about 50 hours a week (almost 12 hours of which is at home); their average salary is $74,000, about the same as that of classmates who work for large companies. This compares with a $69,000 average for everyone, and a median salary of $60,000.

We have learned with sorrow of the passing of our classmate **Joseph M. Van Horn** on September 18, 1983, at the age of 51, as the result of an automobile accident. He was a founder of Codex Corp. in 1962 and of Brattle Instrument Corp. of Cambridge in 1972, where he served as executive vice-president until his untimely death. Our sincere condolences to his family.

On the brighter side, your class secretary and his wife Berna became proud grandparents for the first time in mid-November (a boy). If any other young grandparents want to get that information in the class notes, we'll be happy to accommodate you.—**Wolf Haberman**, Secretary, 41 Crestwood Dr., Framingham, MA 01701; **Joseph M. Cahn**, Assistant Secretary, 389 Bronwood Ave., Los Angeles, CA 90049

54

William Missimer, executive vice-president of Pratt and Whitney, was invited to present the 1983 Towne Lecture at the A.S.M.E. Winter Annual Meeting in Boston. At Pratt and Whitney, Bill is responsible for military and general aviation business, as well as fuel cell operations. . . . Congratulations to Marie and **Lou Mahoney**, who have succeeded in seeing their two children through college and into marriage. Rumor has it that they are now expectant grandparents.

When last seen (in the summer of 1962), **Jack**

Livingston was studying Turkish at Harvard. At that time he was working toward a Ph.D. in Middle Eastern languages at Princeton. Does anyone know his whereabouts or have more recent information on him? . . . **Charles Smith** has managed to keep a boyhood dream going for a lifetime. At Tech he was an officer of the Model Railroad Club and the Electric Railroads Association. Now he works with Louis T. Klauder and Associates in Philadelphia—consulting engineers in railroad mechanics. He writes that "the present high-capacity freight car fleet includes many examples of poor design and poor execution, and insures that I am kept busy." Charles will be at our 30th Reunion and will, I'm sure, be happy to exchange "war stories" with other railroad buffs.—**William Combs**, 120 W. Newton St., Boston, MA 02118; **John Kiley**, 7 Kensington Rd., Woburn, MA 01801; **Louis Mahoney**, 52 Symor Dr., Convent Station, NJ 07961; **Dominick A. Sama**, 28 Chestnut Hill Rd., Groton, MA 01450

56

Bill Northfield, our class president, and some of the other class officers met recently. The consensus was that there was not enough class interaction between five-year reunions. It has been suggested that two mini-reunions be held before the 30th reunion in 1986, one on the West Coast in the summer of 1984 and the other on the East Coast, outside of New England, in the summer of 1985. Any member of the class of 1956 interested in participating in or making suggestions about the how and where of such a mini-reunion should contact **Bob Kaiser**, class co-secretary.

All class members must have gotten their notice of class dues by now. **Ted Korelitz**, our class treasurer, informs me that, while the return to date has been excellent, not all classmates have paid their dues. To those of you who have procrastinated sending your check to Ted, consider this a reminder to pay your dues. To those who have already done so, this is a thank-you note.—Co-secretaries: **Robert Kaiser**, 12 Glengarry, Winchester, MA 01890, (617) 729-5345; **Caroline Disario Chihoski**, 2116 W. Davies Avenue, Littleton, CO 80120, (303) 794-5818

58

When we read Orwell's *1984*, it seemed so futuristic. Now that it's here, what do you think? Write me a note about it and, of course, bring us up to date on your other activities.

Among the notes in our mailbag this month was one from **Martin Victor** saying, "Sorry to miss the reunion, but hope that all my classmates had a wonderful time. Our daughter Beth graduated from Duke Law School and recently married an M.I.T. graduate, Michael Robbin, who is now working toward an M.D. at Duke. Our son Philip received a degree in industrial engineering from the University of Miami. We expect to be finishing up our tour at Homestead A.F.B. this year." . . . Although he had hoped to attend the 25th Reunion, **Tom McClimans** had to pass it up, but sent this note: "We send our good wishes, but there is no way for all of us to make it from Norway to the Reunion. My wife Else and our children have been living in Norway for the past 11 years while I have been working with the River and Harbour Laboratory in Trondheim. During this time I received the Norwegian Doctor Technicae for a monograph, "On the Hydrography, Dynamics and Energetics of Fjords." My last venture to the United States was in 1981 as a visiting professor in civil and environmental engineering at the University of Wisconsin in Madison. My plans to visit **Martin O'Donnell** before returning to Norway were abandoned in favor of red tape with passports—sorry about that, Marty! Else and I now have three children, Else Leona (14), Kari (13), and Ole Thomas (8)."

At Wang Laboratories, **Bob Kolk** has been promoted to the position of senior vice-president. . . . **Jamie Rosenthal** has been named president and chief executive officer of Groupo Continental, a leading financial group in Honduras with interests in banking, insurance, leasing, insurance brokerage, sugar, and newspaper publishing. His family now includes one daughter and four sons, and one of the boys has an interest in attending M.I.T. . . . **Kenneth Smith,** associate provost and vice-president for research at M.I.T., was recently elected a member of the National Academy of Engineering. Ken was recognized for his creative and fundamental research in fluid mechanics and rheology, heat and mass transfer, and professional and educational leadership.—**Michael E. Brose,** Secretary, 59 Rutland Sq., Boston, MA 02118

59 25th Reunion

The absence of this column for the last few months stems from total absence of news from classmates. One joyous exception concerns the birth of Joanna Nichols Richardson on October 12, 1983, to our classmate, **Phil Richardson** and his bride, Diana. Joanna rang in at 6 pounds, 5 ounces; she and her mother are home and doing well. . . . **James M. Snodgrass** is now president and chief executive officer of Estronics, Inc., a subsidiary of Esmark, Inc., in Chicago. . . . **John Poduska** has been appointed chairman and chief executive officer of Apollo Computer, Inc., in Chelmsford, Mass.

If any of you in the Long Island area have an interest in horseback riding but don't get great joy from simply renting a horse and hitting the trails by your lonesome, call me. I am a member of a group that forms a thundering herd once a month and has a lot of fun. Regards to all, and see you at the Reunion in June.—**George L. Barnett,** Acting Secretary, 90 Broad St., New York, NY 10004, (212)363-4600

60

Yes, it has come to this: in just 15 months, we will be celebrating our 25th reunion! Mark the dates on your calendar now: June 6-7, 1985 in Cambridge. It will be a time for renewing friendships within our class and strengthening our relationships to M.I.T. Our reunion chairman is **Timothy Hart** and our reunion gift chairman is **Barry Bronfin**. Tim, you may recall, was the sociologist for our 20th reunion, conducting and tabulating a survey of the class. Barry, who is president of Scientific Leasing, Inc., a lessor of high technology medical, computer, research systems, lives in Wethersfield, Conn. with his wife Cecile, son Michael, 15, and daughter Wendy, 14. No doubt you have heard from him about the Class of 1960 Endowment for Innovation in Education, which will be funded by our 25th reunion gift.

Pat Coady, George Koo, and **George Schnabel** are working with Barry on the reunion gift committee. Pat recently wrote to say, "My wife Judy is director of the Gallery at Workbench, Park Avenue, New York, which specializes in one-of-a-kind, fine handmade furniture. She now experiences 'executive tension' and all the other attributes of the workplace. I had thought I had escaped technology by being in investment banking, but the modern day woodworker is implanting light emitting diodes, epoxy resins, and inlaying plastic laminates. Some of this furniture is on the 89th floor of the World Trade Center. You can see me and the furniture there. Stop by sometime." . . . **George Koo** founded and became president of Microelectronic Business International, based in Mountain View, Calif. last August. He indicates that the purpose of MBI is to establish manufacturing in the Far East for the American electronics industry and to make selected equity investments in emerging high-tech companies. . . . **George Schnabel** is environmental control manager of the North American Region of Rohm and Haas Co. He lives in Radnor, Pa. with his wife and has two daughters attending Penn State University. He is past president of the M.I.T. Club of Delaware Valley and is presently chairman of the M.I.T. Educational Council of Philadelphia. Says George, "I spend my summer weekends at the Jersey shore, part of the time on my boat."

Harold J. Parmelee has been named vice-president and general manager of the New York office of Turner Construction Co. . . . **Soo Tang Tan** is publishing his second book, *College Mathematics for the Managerial and Social Sciences*. He is associate professor of mathematics at Stonehill College in North Easton, Mass. . . . **Howard I. Braun** writes, "I am currently responsible for the New York office of Arch W. Roberts and Co., a municipal bond underwriter. I'm primarily involved in developing revenue bonds for health care and industrial development uses. Both children are now in college, Richard at Ithaca College and Elayna at East Carolina University." . . . **L. Fillmore Mc Pherson III** says, "I work for Schick Safety Razors, Warner-Lambert Co. I'm watching my three children grow up (too fast), and in my spare time I'm active in Naval Research and in the Boy Scouts."

R. Bertman, '60

Richard J. Bertman, a principal in the Boston firm CBT/Childs Bertman Tseckares and Casendino, Inc., has been advanced to the College of Fellows of the American Institute of Architects. . . . **Charles A. Eckert,** professor and head of chemical engineering, University of Illinois, Urbana, has been elected a member of the National Academy of Engineering. . . . **Sidney L. Ossakow** writes, "I am currently head of the Plasma Physics Division at the Naval Research Laboratory in Washington, D.C., and was recently selected as a fellow in the American Physical Society." . . . **Sue Schur** recently was honored by the Preservation Alumni of Columbia University's School of Architecture Historic Preservation Program when she received that organization's communications award, given in recognition of her work in the publishing and editing of *Technology & Conservation*, a magazine she founded in 1976.

Lawrence W. Carr says, "I am now working in the Aerodynamic Research Branch of NASA/Ames Resarch Center, doing research on the characteristics of unsteady turbulent boundary layers and dynamic stall of helicopter rotor blades." . . . **James K. Heeren** has received U.S. Patent 4,357,146, for a synthetic motor fuel. . . . **Richard J. Higgins** says his book, *Electronics with Digital and Analog IC's* (Prentice-Hall, 1983), is doing well in the "electronics for scientists" market. He said he will be at M.I.T. next year (National Magnet Lab and Submicron Structures Lab) and looks forward to renewing old acquaintances.

Sheldon L. Epstein writes, "We continue to expand our business, Epstein Associates of Northbrook, Ill., which specializes in custom microelectronics. When in Portland, Ore., I stopped to see **Eric Jorgenson,** who is corporate counsel at Tektronix, and **William Baer,** who is an ophthamologist. Bill and his wife Sydney have two children, a daughter, 3, and a son, 18 months. After seeing them, Sue and I are glad ours are grown!" . . . In the same mail comes a note from **Douglas L. Bashioum,** who says, "I've been with MITRE

Corp. for the past ten years. The good lord blessed my wife and me with child number 5 (son number 3) about three years ago. The last of the first four graduated from high school this past June. The oldest made us grandparents about two years ago. Needless to say, life is very interesting and busy!"

J. Goldstein, '60

Joseph I. Goldstein has been appointed vice-president for research at Lehigh University. Joe, who received his B.S., S.M., and Sc.D. degrees in metallury at M.I.T. has been on the Lehigh faculty since 1968, following stints at NASA Goddard Space Flight Center and the Smithsonian Astrophysical Observatory. His major research has been in the areas of solid state diffusion and diffusion controller transformations, . . . **Gordon C. Shaw** writes that he is a professor in the Faculty of Administrative Studies, York University, Toronto, Canada. He is doing research on Canadian transportation issues and has just completed a publication for *Transport Canada* on the number of Canadian Great Lakes dry-bulk freight vessels to be required in 1990.

J.H. Goldberg is vice-president of nuclear engineering and construction for Houston Lighting and Power Co. . . . **Eric T. Rinkjob** has left Storage Technology Corp., where he was executive vice-president and director of engineering and manufacturing operations, to become president and chief executive officer of Prolink Corp., Boulder, Colo. . . . **Clay T. Whitehead** has left his post as president at Hughes Communications, Inc. to pursue his own business. . . . **Anthony M. Fazzario** is marketing manager for organofunctional silicones in the silicones and urethane intermediates division of Union Carbide Corp., Danbury, Conn. . . . **Robert E. Stoeckly** writes, "I've taken a new job as physicist at Kaman Sciences Corp. in Santa Barbara, Calif., where I live with my wife and 3-year-old daughter."

Howard Hornfeld writes, "In addition to running a reasonably successful plastics consulting firm (CONSULTEX S.A.) for nine years, I have been very active in the world of theater in Geneva (in English). I have also been trying to keep the M.I.T. Club of Switzerland in action, although that is only a semi-viable group. My wife Carolyn is associate desk editor for a chemical journal which she does at home in 'free time.' " . . . Another theater buff in our midst is **James Walker,** who this past summer was fight choreographer at The Theater at Monmouth in Maine. He staged the fight scenes in their productions of Cyrano de Bergerac, *Twelfth Night* and *Hamlet*, in addition to performing in the company. . . . **Linda Greiner Sprague** writes, "I'm still at U.N.H., teaching and serving as director of our executive programs. My sojourn in China—teaching in northern China and visting dozens of factories as part of the business of developing teaching materials—has inspired me to further international travel. I'll be teaching at IMEDE in Lausanne, Switzerland, in 1984-85. Son James is a senior at M.I.T., daughter Barbara is a sophomore at U.N.H. Chris (**Christopher R. Sprague**) lives at the Cambridge Nursing Home and now has an Apple computer which has been rigged up so he can use it." . . . **Vernon Yoshioka** ran for the position of the San Diego Community College District B last September and lost by only a small margin.

Once again, a reminder for our 25th reunion! As my daughters would say, "be there or be square!" In the meantime, write to tell us what you're doing and what you'd like to do at the reunion.—**Noel S. Bartlett,** Secretary, 15320 Edolyn Ave., Cleveland, OH 44111

62

Steven Brams has been busy writing books—two in 1983. One is *Superior Beings: If They Exist, How Would We Know? Game-Theoretic Implications of Omniscience, Ominipotence, Immortality, and Imcomprehensibility*, published by Springer-Verlag. The other is *Approval Voting*, coauthored by P.C. Fishburn and published by Birkhaeuser Boston. Approval voting is an election reform that allows voters to vote for as many candidates as they like; it is scheduled to be used in the Pennsylvania Democratic Party's presidental straw poll. . . . **Glenn Buckles** recently retired from the U.S. Air Force and is now studying at the Amos Tuck School of Business Administration at Dartmouth. . . . **Rudolph Gawron** has been with General Electric for 20 years, the last seven in Philadelphia. He recently became technical director for General Electric Professional Services in New York City. He enjoys the increased work pace, although the daily commute can be very trying. . . . **Barry Roach** has written to update a partial news release I reported last October. He is now vice-president and chief financial officer of Raychem Corp. in Menlo Park, Calif. He commutes from nearby Palo Alto, where he and his wife Kate are remodeling their house to accommodate three children—Molly (8), Sarah (6), and Daniel (4)—along with assorted cats and dogs and neighborhood hangers-on. He is a director of the San Francisco Ballet and the San Francisco Zoo and writes that if anyone has any tutus or peanuts, send them on. He encourages any classmates near San Francisco to give him a call. . . . **Bardwell (Bojey) Salmon** joined Computervision last July as division vice-president of mechanical machinery, with a new office in Bedford. Computervision is a world leader in CAD/CAM, the automation of design and manufacturing processes.—**John Prussing,** Secretary, 2106 Grange Dr., Urbana, IL 61801

63

Hey, guys and gals—lots of news this time, so here we go. **Stu Madnick,** associate professor at the Sloan School, is co-author of "Knoware," software for IBM PC and XT that is said to introduce the user to computers through a Monopoly-like game. . . . **Jim Taylor** has been a coach at Tech since graduation, and recently—according to a press release—was appointed head coach for interim squash and men's tennis. . . . In September, **Don Dreisbach** and his wife had a 9 1/2-pound son, their first, whom they named Tristan Ira. Congratulations from fellow '63ers. . . . Also with a son under one year old is **Robert M. O'Donnell,** who is manager of systems engineering for RCA in Moorestown, N.J.

This past summer **Pat Marzilli** and her husband, Luigi—both research chemists—were at the Technical University in Munich, Germany, where she reunited with her Tech roommate, **Cindy (Kolb) Whitney,** who does research in robotics. Pat and Luigi are now at Emory University, but will return to Munich next summer. . . . **Georges DuVal** is finishing a residency in orthopedic surgery at Bethesda (Md.) Naval Hospital, living in nearby Silver Spring, and enjoying all-weather back-packing with his bride of less than a year, Pat. . . . **Allen Meyer** went with his wife, Nancy Russo, to a meeting of the American Psychological Association in Anaheim and met **Andy Campbell** on the trip. That was early in the summer. Later on, Nancy "got her leg broken" at what must have been quite a boisterous picnic. In any event, he is at last report up to his eyeballs in work doing all the household chores and also helping Nancy with her job. That's a blow for women's liberation, Al!

Ed Dudewicz is at Syracuse University adding computer-related material to a course in probability and statistics for non-math majors. He recently was selected as a fellow of the Lilly Endowment "Focus: Excellence in Teaching." . . . A strange coincidence is reported by **Warren Sewall.** It seems he and **Seth Malin** have both been practicing medicine the past four years in the same county in eastern Pennsylvania, although their paths had not crossed since graduation. However, Seth and his wife, Judy, are now having a house built in Upper Providence, directly across the street from Warren and Phyllis!

You might remember that last time I boldly suggested the need for Congressional office of science and technology. Well, about two weeks after I mailed the piece, I read in the papers they have one already—but I don't think anyone is making much use of it. In the November *Scientific American* an M.I.T. undergraduate and physics professor argue convincingly that the "window of vulnerability" to Soviet nuclear arms is based on bizarre assumptions about accuracy and reliability of the nukes. And yet Congress keeps voting more money for U.S. nukes. There, that ought to stir up some mail.—**Phil Marcus,** Secretary, 2617 Guilford Ave., Baltimore, MD 21218

64 20th Reunion

Greetings '64. Your long lost secretary has found his pen and some class news as well. Sadly, I begin with the news that two of our classmates have passed away. **Carl Uhmacher** advises me that **Noel I. Morris** collapsed and died while on an outdoors trip last October. I have no other details at this time. . . . **William R. Devereaux** was shot to death in Meridian Hill Park in Washington, D.C. in 1980. Bill was a practicing patent attorney, having earned a law degree from George Washington University after leaving M.I.T. He was also commander of the District's American Legion. I am reporting this now because of a news clip from the *Washington Post* which discussed the conviction of the two men found guilty of the slaying.

From the news clipping bag: Formerly head of business services at Fermi National Accelerator Laboratory in Batavia, Ill., **Bruce Chrisman** is the new vice-president for administration at Yale University. His responsibilities will include the operations (including buildings and grounds), purchasing, food and printing service, personnel, and communications.

Lots of "notes on my activities" from the Alumni Fund envelopes: **Alexis Bell** has been on the faculty of the Department of Chemical Engineering at the University of California at Berkeley since 1967. He has been department chairman since 1981 and was the recipient of the 1983 Professional Progress Award of AIChE. . . . **Robert Brooks** has announced the opening of a new consulting practice specializing in operations research and computer modeling applications in transportation and energy. His address and phone: 4209 Santa Monica Blvd., Suite 201, Los Angeles, CA 90029, (213) 663-4831. Good luck to you!

Leo Cardillo writes that he and his entire family are alive and well in "beautiful downtown Monrovia"! They're looking forward to an eventful few years in Africa, but also to some R&R in July 1984 back in Boston. For all you marathon fans, Leo's time in the April 1983 Boston Marathon was 3 hours and 6 minutes. . . . **Frank Cornelius** has traded mathematics for a law practice. He recently argued the first trade secrets case in front of the Michigan Supreme Court. His offices are located in Detroit's Renaissance Center, where his practice revolves around pension/profit-sharing work and technical litigation. . . . **Kenneth Harrow** is a professor of humanities at Michigan State University. He has just returned from Senegal where he conducted research for a year on African literature under the auspices of a Fulbright

Research Fellowship.

David J. Houpt is general manager of SIE-Geosource, a well logging and wire line equipment company in Benbrook, Tex. He has three children—16, 14, and 17 months. . . . After 9 years at Sandia National Labs, **Henry Rack** has joined Exxon Ent. Material Division. The company has changed hands and is now Arco Metals where Henry is manager of metallurgy. . . . **Gary Seligson** is a partner in Comet Products, Inc., part of the plastics industry, in Chelmsford, Mass. Married since 1964 to Amy, they have two children—Karen, 14 and Daniel, 12—and live in Lexington, Mass.

We even have a couple of class heroes this month. . . . A quick note from **Joe Kasper** who heard we were looking for a volunteer for the job of class secretary. After ten years the job is now open. It's been fun, interesting, frustrating but worthwhile. Thus, if Joe is willing to volunteer, it probably will be a landslide victory for him at our 20th reunion! The next article you read in this column may be ghostwritten; who knows! . . . Our other class hero is **Bob Howie**. We wrote about Bob when the MASSTOR Systems Corp. was being conceived and founded. This past March MASSTOR went public at $16 per share. Bob is quite proud (and also very pleased) to report its market value at $27 when he wrote to me. The company sounds quite successful, has over 200 employees, with M.I.T. and Stanford grads topping the list. MASSTOR manufactures storage products for large scale computers (trillions of bytes in a box slightly larger than a few refrigerators) plus high-speed inter-processor networking for IBM, Univac, CDC, DEC, and Honeywell processors. Bob is also a staunch supporter of the current national administration and its economic policies, apparently believing that such policies helped provide the opportunity he has recently exploited and enjoyed. Good luck, Bob!

Today is December 2, and I am on my way to Kalamazoo, Mich. this afternoon, for the first time ever, to visit my wonderful sister (who usually visits Washington). The Xmas party season begins tonite as well for many of us.—**Steve Schlosser**, Secretary, 11129 Deborah Dr., Potomac, MD 20854

65

Two issues ago, I wrote a column saying there was no column. Last issue, again with no material, I decided to forget the whole thing. This time, we have five items. If you want a column, you'll just have to send me a postcard.

Chris Ebbe reports that he is still training psychologists in public sector mental health in San Bernardino, Calif. It can't be too tough—he has taken advantage of the Southern California location to vacation in Hawaii the last two years. . . . Enjoying the Northern California environment is **Bill Cohen** who reports that he is residing in Sunnyvale and is into snow skiing at Tahoe (40 days last winter) and water skiing in the Sacramento Delta in the summer. In between, there's bicycling, backpacking, and even roller skating—all the things Bill missed while at M.I.T. Bill has been single for the last five years, but has a 10-year-old boy, Ian, who does these things with him. Bill currently works for himself in the area of tax shelters and other investments. . . . **Ted Young** is professor of measurement technology and instrumentation science in the Department of Applied Physics at Delft University of Technology, the Netherlands. Ted and Mieke have three children, Heather (14), Aaron (12), and Michael (2). Ted says that having lived in Boston, San Francisco, and now Holland, he finds Boston the most European of American cities. He reports that it is easier to move from Boston to Holland than Boston to California.

Alan Pogeler reports that he and Jane have been married for 16 years and have two sons, aged 7 and 2. Alan works as director of planning for Aerojet-General Corp. (Defense Products) in La Jolla, Calif. He says they are lucky to live and work near the ocean in the San Diego area, "the best city in the U.S." Alan plays golf and gardens in his spare time; he reports that computers have taken over his life; with one at work and another at home. Alan says his next-door neighbor is Tom Seay, '64. . . . A press release reports that **J.D. Roach** has left his position as a vice-president and director of Booz, Allen and Hamilton to become president and chief operating officer of Braxton Enterprises, a new venture capital firm that will operate out of Houston, where J.D. lives.—**Steve Lipner,** Secretary, 6 Midland Rd., Wellesley, MA 02181

67

Steve Berger is a systems engineer with TRW, Space and Technology Group, in Redondo Beach, Calif. His work involves propulsion studies for the NASA gamma ray observatory project. . . . Sheri and **Jeff Schoenwald**'s second child, Elyse Rose, was born June 24, 1983. Big brother Josh is 3 years old and 34 pounds of trouble. Jeff is doing research on sensors for robotics and intelligent machines at the Rockwell Science Center in Thousand Oaks, Calif. . . . **David Benson** is passenger marketing director for P&O Ferries Ltd. in London, England.—**Jim Swanson**, Secretary, 878 Hoffman Terr., Los Altos, CA 94022

71

Charles A. Eby married Cynthia Morrill on October 15, 1983 in the M.I.T. Chapel, and they honeymooned in Greece and Egypt. He is group director of commercial business-to-business marketing at Epsilon, Inc., in Burlington, Mass. . . . **Joseph N. Fields** received a Ph.D. in physics at Stanford, has a daughter, Emily, born in March 1977, received an M.D. at the University of Miami in 1982, and is now at Washington University, Mallinckrodt Institute of Radiology, doing residence in radiation oncology. . . . **Joe Martin** and his wife Cheryl, '72, had their fourth daughter, Audrey, on July 28, 1983. Joe works for the American Hospital Association in Chicago. Congratulations to Joe and Cheryl for an obviously fruitful marriage.

Marc Roddin writes, "I am now in the process of making a career switch from consulting to a staff analysis position with a manufacturing company. Fortunately, there are hundreds of interesting high tech companies located within 10 or 15 miles of my home in Mountain View, Calif., so I've been reading about and talking with quite a number of them. Otherwise, my recent accomplishment has been singing in the choir at my church. I've had absolutely no previous singing experience, so it is fun to learn what to do by looking at the music (which I never knew how to read before), listening to those around me and paying attention to our director." . . . **Etan Bourkoff** is presently assistant professor of electrical engineering and computer science at the Johns Hopkins University in Baltimore.—**Hal Moorman**, P.O. Box 1808, Brenham, TX 77833

72

Cryil Draffin joined Greater Washington Investors, Inc. this year. It is a publicly held venture capital company where he "evaluates promising technology-based companies and makes investments in the ones most likely to be successful in their market niches." . . . In the same field, **Fred Fruitman** is a vice-president of Investors in Industry Corp. in Boston, the U.S. subsidiary of a London venture capital firm owned by a consortium of British banks. . . . **James L. Davis** and his wife Jill have two children, Sebastian, 3, and Tristan, 1. . . . **David Crary** writes "I am working in Lexington as district sales manager for American Microsystems, Inc. Selling integrated circuits has been a lot of fun. I still live in Boston one block from the old Delta Tau Delta house and was married in April to Virginia Byron. The best man was my old friend **Jim Gurley** and attendees included John Dieckman, '71, **Mike Stauffer**, Warren Sherman, '73, John McGoldrick, '73, Frank Guzikowski, '75 and Jim Shields, '71. I'm enjoying married life with Ginny and still love New England."

William Gahl is a pediatrician and biochemical geneticist with a Ph.D. from Wisconsin now working in the human genetics branch of the NICHD in Bethesda, Md. He writes, "My specific area of interest is lysosomal membrane transport, particularly as studied in cystinosis, a disease in which cystive transport is defective. Mary and I are expecting our fourth child around Turkey Day." . . . **Robert Goodof** has joined the Investement Research Division of Eaton Vance Corp. with responsibilities in the chemical and instrumentation industries. . . . **Lawrence Bacow** is co-author of *Facility Siting and Public Opposition*. As well as being a professor in Course XI, he is a member of the Massaachusetts Hazardous Waste Facility Site Safety Council.

Michael Rowny is vice-president and treasurer of MCI Communications Corp. in Washington. . . . **Richard Arratia** is living in Venice, Calif. and teaching math at USC. He reports, "Charlie Blair was right—I am a farmer. My backyard bananas just had pups." . . . **Leslie Bauer** received an M.S. from Rutgers last May. . . . **Cheryl Davidson Martin** and her husband Joe had their fourth daughter, Audrey on July 28. . . . **Don D'Amico** writes, "My wife Kathy, 1-yr-old son D.J., and I are settled in Quincy, Mass. following my fellowship in vitreoretinal surgery in Miami. Enjoying being a dad and my work at the Diabetic Retinopathy Unit at Mass. Eye and Ear."—**Dick Fletcher**, Secretary, 135 West St., Braintree, MA 02184

73

This was the month for news. **John Fort** has been elected chairman of the board of Tyco Laboratories. John was president of their Simplex Wire and Cable Co. of Portsmouth, Oh. . . . **Dan Fylstra** has been founder, chairman, and CEO of Visicorp, maker of "application software products for personal computers." How modest! . . . **Dean Sullender** has been working for H-P in the health care productivity division. His latest project is creating software to handle prospective payments from Medicare. He says H-P is "a great place to work." I've heard that before. . . . **Eric Suuberg** is on the faculty of the Division of Engineering at Brown University, where they are starting a new chemical engineering program. He sends "best regards to the Bexley Gang." Seems that Eric's old room is now Bexley Desk!

John Edighoffer is active in free electron laser research at TRW. This past summer he demonstrated his first tapered wiggler free electron laser at Stanford. John is married to Ginger Harkness, a computer science graduate student there. . . . **Mike Scott** notes 1983 as an eventful year for him. He is manager of 25 software engineers in R&D for H-P. This summer a slight hearing problem uncovered a benign tumor requiring brain surgery. Mike reports that his hair has grown back and, after missing his normal exercise routine, he is back in reasonable shape. . . . **Carl Rosenberg** is still in California, still in academia, and supporting himself by selling pencils. His handwriting, it should be noted, has not suffered. . . . **Roger Lace** married Patricia Webber last April and is now assistant vice-president of investments at Confederation Life of Toronto.

Peter Shanahan and wife Suzanne are enjoying their first child, Meghan Elizabeth, born last March. He is at Environmental Research and Technology of Concord since his Ph.D. at Tech in October 1981. . . . **Susan Stopek,** who still doesn't remember me, is living in Port Jefferson (state unknown), where she began her psychiatry

practice last September. She is happily married with two children. . . . **Michael Cheng** has been promoted to group product manager at Rolm Corp. . . . **Steven Book,** married for 12 years to Maureen, is expecting their first baby in January. While MBAing at Berkeley, he is a computer systems consultant and founder of a software company. **Richard Galik** is still an assistant professor of physics at Cornell. He sees two other M.I.T. types on the faculty—**Frank Keil** and Pete Wolczanski, '76. Richard is a volunteer assistant coach on the C.U. lacrosse team.

David Simen is doing systems engineering at Bell Labs soon to start on a new project. He was married on May 1 to Margaret Ingate. They are expecting in April. . . . **Tessa Lebinger** lives with her husband Marty and 3-year old daughter Tzipporah in New Rochelle, N.Y. She is a pediatric endocrinologist and he a psychiatrist at Montefiore Hospital in New York.

Chapel Hill is now under roof, though not under occupancy. Give it time. In the meanwhile, I have joined a barbershop quartet, the Rising Sons, whose bass lives in Spotsylvania, lead in Fredericksburg, baritone in Culpeper, and tenor (y.t.) in Warrenton. Those rehearsals can be a bear! We're to compete in the Virginia State competition this Friday—wish us three months belated luck! Ruth is now teaching in the Christian school our sons attend. That means awakening at 5:45. That's a.m.! Yuk! . . . Write!—**Robert M. O. Sutton, Sr.,** Secretary, 24 Princess Anne Ct., Warrenton, VA 22186

74 10th Reunion

Here we are in 1984. It is the year of "reunion-speak." There may be a class struggle for space so be sure to reserve your "10th Party" membership early. The official (at this early date consider it only semi-official) party line will be presented in a series of vignettes modeled after popular cinematic themes.

Friday evening (the first scheduled event of the reunion weekend) will begin with registration (*We're in the Army Now*). Around eight o'clock, there will be the dedication ceremony for the Class of 1974 Health Fitness Center (or some name that comes out to about the same thing). The proceedings will resemble the action from the movie *Health*. Afterwards, there will be a combination of *American Graffiti* and *Rollerball*: munchies and end-to-end and rollerskating action in the athletic center.

Those who can handle all the excitment may proceed to the next day's activities. Saturday's picnic at Endicott House will be a gala event with the setting a near match to the opening scenes from *Women in Love*. Saturday evening at eight o'clock will be dinner and who knows what at Averof's in Cambridge. *Casablanca* all over again.

If your level of excitement still hasn't worn off, there will be a late night soiree on or very near the campus for the *Night People*, or is it *Night of the Living* . . . ?

Sunday will bring us all back to reality with a fabulous brunch at the boathouse on the Charles. The event will really be the class business meeting and election in disguise so that it may take on the characteristics of the film *The Candidate*. as you leave for home after all this excitement and chills, you may feel similar to the astronaut in the final scene of *Alien* as the beast is left behind and the escape finally made . . . or has it? Let's face it: you will never escape from the Class of 1974. So be there or be square.

Congratulations are in order for **Joseph Sulmar** who is celebrating the end of his first year as proprietor of Sulmar Systems Engineering in Belmont, Mass. A consulting and contract firm, Sulmar Systems provides technical assistance in the specification, design, and development of electronic products. Joe looks forward to moving ahead with the development of proprietary products during 1984, and to the continued growth of his contract work in the areas of telecommunications and digital video.

Lionel Goulet writes that is still single and still "lovin' it." He continues, "Never danced in my life until last December (1982). Now I'm in a swing dance performance company dancing three nights a week (for money!). It's my interesting observation that five years ago people asked, 'What should I do with a home computer?' Now they ask, 'Is 64k enough memory?' And often the answer is 'No!'" I agree but I can't dance that well.

So come on down to your 10th pahty and take a vacation from the real world. If you haven't received an official letter from the class about the reunion, please let us know. Your address may be incorrect in our files. Please bring your children but not your "Big Brother."—Co-secretaries: **James Gokhale,** 12 Pond Lane, No. 54, Arlington, MA 02174; **Lionel Goulet,** 21 Melville Ave., Dorchester, MA 02124

75

Peter Schulz is in his second year as an assistant professor of physics at Georgia Tech. He says around there M.I.T. is known as the Georgia Tech of the North. . . . **Jeff Lang** is an assistant professor of electrical engineering and computer science at M.I.T. . . . **Alex Pankow** and his wife, Susan, moved into a new home in Rockville, Md., about a year ago. They had their first child, Natalie Marie, in May 1983. "Parenthood is treating us well and we are enjoying our little Natalie quite a bit."

Michael Stiefel is working in the area of electrical CAD/CAM for Prime Computer in Framingham, Mass. He and his wife recently bought a condo in Brookline. . . . **Eve Higginbotham** returned to Boston after living in Puerto Rico, San Francisco and New Orleans. She is doing a fellowship at the Massachusetts Eye and Ear Infirmary.

After graduating from M.I.T. **Gordon Freed** attended dental school for four years, spent three years with the U.S. Army at Ft. Devens, Mass., and now has been in private practice in Amherst and Belchertown, Mass., for about a year and a half. He met his wife, Barbara, in dental school; they have a 20-month-old curly-red-haired daughter named Beth Ann.

During the past twelve months many of us have turned 30. Congratulations! A milestone worth celebrating. So what if we've got a few wrinkles; they help create that wise and experienced look.—**Alex Castaldo,** Secretary, 929 Massachusetts Ave., Apt. 12D, Cambridge, MA 01239

76

Greetings from Hong Kong. Both the mails and the telephone have yielded some news. A note from **Neil Kaden:** "Still working for Northern Telecom in the Dallas area. This year my group is working on software for cellular radio handoff and operator services, as well as our mainstay of database and man-machine interfaces. As software development project manager for SBS and ITT I'm getting a lot of exposure to our customers, our manufacturing people, and the thrills and chills of meeting a contract; fascinating stuff—already my hair is starting to turn grey." . . . **Steven Goode** received a juris doctor (J.D.) from the New England School of Law. He did it by going part-time (evenings) while being the assistant director of the Office of Sponsored Programs at the 'Tute. In addition, he was on the Dean's List throughout law school and was granted his degree cum laude. He, and his wife, Meri Whitaker, live in Cambridge and have a daughter, Cary Lu.

And speaking of children, I spoke to Michelle ('78) and **Gary Buchwald**. They recently had a second child, Jacqualine, who apparently inherited Gary's red hair. They live in Sharon, Mass., and Gary is still with Analog Devices. Now, near as I can decipher my hastily scratched notes, he is ensconced in a management role with eight people working for him. Michelle has gone back to work part-time with John Hancock as an actuary.

From **Martin Brock**: "I have moved back to New Rochelle for a while and am taking things easy for the moment. I spend most of my time doing my own research, writing and studying—largely in mathematics. If **George Oparah** is out there, please try to get in touch with me." . . . **Ingrid** (nee **Klass) Gorman** writes: "James J. Gorman, '75, and I are the very proud parents of Emily, born November 8,1982. I'm still working at Draper, and Jim is back at AVCO Systems division. Joan Whitten, '80 and John Miller, '74, are also parents now (a son). We also see **Chris Tracey**, who is now at Klossman Instruments in New Hampshire." . . . **Robert Lambe** is now in family practice in Plainville, Mass., with their second child due January 1, 1984.

Alan Dubin is "currently working as a mechanical design engineer for Allied Fibers and Plastics Co., in Morristown, N.J., specializing in finite element computer analysis for engineered plastics." . . . **Edward Kashdan** earned an M.S. in environmental engineering at the University of North Carolina, Chapel Hill in 1977. He is currently employed at the Research Triangle Institute and engaged in research in aerosols and air pollution.

Mark Koupal sends word that "after getting bored with public accounting early this year (1983)," he joined Spectrum Medical Industries in May. He is the controller of a group of companies making lab equipment with offices in California, Chicago, Houston, and New York.

Carol Steiner reports that she is finally a Ph.D. (that's in chemical engineering from the University of Pennsylvania). She works for Hercules, Inc., in polymer research and lives in Philadelphia, Pa.

As for your secretary, a great deal has happened since the last issue of the Notes. Merrill Lynch and I got a divorce. To be frank, I am a bit disenchanted with the way some things are done in the futures trading departments of the major Wall Street firms. After winding up affairs in Hong Kong, a city I have grown to love as much, or even more, than Boston and New York, I went on to Geneva to explore several business ventures. I don't think I'll give up trading all together; I am too addicted to it. But at this juncture I am either going to go private for a very small number of investors or just trade for myself.

The foreign exchange, metals, heating oil, and crude oil markets are particularly jumpy. It appears from a Swiss vantage point that OPEC, which will be meeting here shortly before I leave, is coming unglued. Of course, violent economic and/or political disruptions are a trader's friend. Where there is movement, there is the opportunity for speculative profit. And in that lies both the pleasure and the agony.

But the Swiss winter sun is shining, and even though I do not have a job in the classic sense, there are opportunities to examine. However, I do not think that this time I shall work for a large, Fortune 500 type company, as the politics at the policy level are too much of a bore and distraction.

In the interim, there is a Swiss Franc futures trade I must finish up and touring to do. Due to my jumping around from place to place, please send news to me in care of the *Review*. Your cooperation in helping to assemble news will be greatly appreciated as my effectiveness has been somewhat reduced by all the traveling I have done and am probably going to do.—**Arthur J. Carp,** Secretary, *Technology Review*, Rm. 10-140, M.I.T., Cambridge, MA 02139

77

Class secretary **Barb Crane** is on special corporate asssignment in Japan for a couple of months. Be-

fore leaving, she asked me to write the class notes for this issue. So, if you're dissatisfied with what you read, rest assured that the condition is temporary.

There's a lot of news from the California contingency of our class. Congratulations to **Steven Spiro** and his wife, Marla, for the birth on November 6 of a baby boy, Joel Allen—their first. In addition to helping care for the new arrival, Steve is finishing his last year of anesthesia training in Sherman Oaks and hoping to stay in the Los Angeles area to start his practice. . . . **Peter Cunningham** has been selected for a Hughes Aircraft Co. post-graduate fellowship. A Hughes technical staff member, Peter will pursue a master's degree while the company pays him for his education. . . . **Michael Waldman** is now Professor Michael Waldman. After earning his doctorate in economics at the University of Pennsylvania last spring, he accepted an assistant professorship in the economics department at the University of California—Los Angeles. In between graduation and his move to California, Mike married Karen Voris. . . . **Jake Krakauer** has begun a career with Megatek Corp., a manufacturer of computer graphics equipment, in San Diego. He earned his M.B.A. from the University of Viginia last spring and took a ten-week journey through western Canada and the U.S. Pacific Northwest before arriving in southern California. He reports that, as a marketeer, business is fast-paced and keeps him on his toes. . . . **Louis Bernstein** has passed his professional engineer exam. He's now working for O'Brien Kreitzberg, a construction management firm, as a structural concrete inspector for the California Street Car Rehabilitation Project. . . . **Tom Mills** continues his psychiatric residency at the University of California.—San Francisco. He writes that he does a lot of teaching, writing, and clinical work. He's also singing with a civic chorus and is active with the Bay Area Physicians for Human Rights.

Back in Boston are reports from four classmates. **Esther Horwich,** who recently surprised me at home with a telephone call on behalf of the M.I.T. Alumni Fund, is an attorney in Boston. She's learning to scuba dive and says that "there is nothing quite like being in the Atlantic in November." (Those in warm, sunny California may have to think a moment to recall what she means.)

Alberto Sadun expects to complete his Ph.D. in physics from M.I.T. in June. He's trying to decide where to conduct his post-doctorate research in astrophysics. . . . **Jonathan Green** writes that he returned to Boston a year ago and is fighting off the proverbial digital hounds, doing solid-state physics research in the Analog Devices Technology Group at Lincoln Labs. . . . **Jeff Young** continues his efforts with the Depression of the Central Artery and Third Harbor Tunnel Project for the Massachusetts Executive Office of Transportation and Construction. He offers a special "hello" to everyone from N.R.S.A. and asks for a phone call at the office from any classmate venturing into downtown Boston on a weekday.

Believe it or not, there are a few of us not residing in either California or the Boston area. **Daniel Higgins** is in his fourth year of general surgery in Philadelphia. . . . **Nina Cahan** has recently finished a residency in family practice on Long Island and is now working for CIGNA in Dallas. . . . **Helen Hart** is doing graduate work in astro-geophysics at the University of Colorado. She's studying the atmosphere of Jupiter and chairing the program for the Case for Mars II Conference.

Finally, your author-for-the-month has been promoted into the field organization at AccuRay Corp. and is traipsing around the nation's aluminum and steel mills installing nucleonics-based, sheet metal thickness measurement systems. I'm also finishing a three-year term on the Greater Hilltop Area Commission, Columbus' neighborhood city council for its west side of town. And, still doing a little running, I've proven that the 5-minute mile remains obtainable.—**Dave Dobos,** Secretary, substituting for **Barb Crane,** Secretary, 6431 Galway Dr., Colorado Springs, Co 80907

78

Welcome to this month's gossip column. Let's start with **Lillian Lin**, who's in Seattle, adding new letters after her name. So far she's got seven (S.B., S.B., M.P.H.—from the 'Tute, the 'Tute and Harvard School of Public Health, respectively), and she's out to make it 10 with a Ph.D. in biostatistics from "U. Dub." (University of Washington). "Back to poverty and not getting enough sleep," she writes. "Seattle is beautiful—when it's not raining." She sent me a boring postcard claiming she saw the sun—but the sighting was unconfirmed.

Moving east from Seattle, we find **Steve Piet**, who continues to live under the delusion that Idaho is the "real America." Steve loves his new life there; he says, "The intermountain west—Montana, Wyoming, Idaho, and Utah—are beautiful and full of friendly people." . . . Jumping farther east, we reach Champaign/Urbana, Ill., where **Nancy Everds** is in her second year of veterinary school, "working very hard and having a wonderful time. Veterinary medicine is pretty much like medical school—except there are a lot more species." Nancy sent me a wonderful boring postcard of a flying-saucer shaped campus building.

Another postcard came from our own fire chief, **Frank Murphy**. Frank and his new bride honeymooned in Honolulu, soaking up sunshine, surf and Mai Tais. Frank is the youngest lieutenant in the history of the Cambridge Fire Department, and he's working his way up to commissioner. . . . A note from **David Bates**: "After working two years as an international economist for the First National Bank of Chicago, I have returned to Princeton to complete my doctorate in economics."

Doctor News (we've got a lot of M.D.'s!): **Barbara Ostrov** writes, "I'm an intern in a program that includes both internal medicine and pediatrics. I rarely have time to myself and, like most interns, I usually sleep when I do. I must be crazy, though, because I'm enjoying myself." . . . **Michael Waxman** is doing an ophthalmology residency at New York Medical College. He recently ran into **Yvonne Tsai** at a course for ophthalmology residents—she's doing her residency at Roosevelt-St. Lukes Hospital, also in New York City. . . . **Jeff Snow** is a recent M.D. too. He writes that "change in career goals has led me to Cincinnati, to finish my training in surgery." Jeff invites nearby classmates to contact him for a get-together. . . . **Larry Gordon** writes to say hi from chocolate town—Hershey, Pa.—where he's in his second year of a family medicine residency at Hershey Medical Center. . . . **Vincent Paolino** just graduated from Harvard Dental School. Vinnie has opened a practice in Haverhill, Mass., and is a research associate at Boston's Forsythe Dental Center.

Dan Zwillinger had a fairly uneventful 1983. From New Year's Day to April 1, Dan did Africa—"from Cape to Cairo." After that the real adventure—two weeks of hunting jobs (an endangered species, I hear) back in the States. After that, four and a half months of traveling through India, Nepal, Southeast Asia, China (up to the Great Wall), Japan and Alaska. Dan ended up in Troy, N.Y., where he is now an assistant professor of mathematics at Renselaer Polytechnic Institute. . . . Another classmate professor: **Rob Milne** got his doctorate from Edinburgh University, was promoted to captain in the Army, and was then appointed professor at the Air Force Institute of Technology. Rob keeps himself busy by consulting on artificial intelligence for the Army and Air Force and by mountain climbing around the United States. . . . **Gene Allen** tried to leave the Navy, but was "delayed" by a drunk driver. His recovery, expected to take at least two months, is going well, and he expects to be a civilian any day. By the time this is published, Gene should be in Washington, D.C., working for Booz-Allen and Hamilton. . . . Also in D.C. is **Bernie Alpern**, doing various projects in travel demand forecasting for COMSIS Corp., a small transportation consulting firm.

Another boring postcard arrived today, this one from **Mitch Hollander**. Mitch, who lives in Cambridge, was in Florida visiting **Paul Malchodi**, so they sent me a card from "Communicore" at Future World in Disney World's EPCOT Center. Keep those boring postcards coming, folks. . . . I recently ran into H.T.F. (also known as **Harry Carter**) at the Coop record department. H.T.F. is sharing an apartment with **Mark Schmelz** in Somerville.

Pat Brown and husband Tom "Touchdown" Davidson, '77, have moved to Summit, N.J. Pat is working as a senior process engineer for Foster Wheeler Energy Corp. and supporting Tom, who's going to Rutgers for another graduate degree. . . . Kudos to **Janet Freeman**. Janet was awarded a fellowship for a graduate degree by her employer, in L.A., Hughes Aircraft Co.

Don Mellen is still with Bell Laboratories, working mostly with hardware and printed circuit boards for new products. His wife is also at Bell Labs, and they have two children—2 and 3 years old. He's on the board of the day-care outfit where their kids spend workdays. . . . **Milt Roye** was at M.I.T. in October to recruit students to work for the General Motors Tech Center. . . . **John Gullotti** is setting up a blacksmith shop in his home, enlarging on his work as a welding engineer at General Dynamics Electric Boat in Connecticut. He still has two sheepdogs, and is leading the "quiet country life" with his wife Helen.

Mark Bye now works for Air products and Chemicals, Inc., in Allentown, Pa., commuting 75 miles to work each way. He and wife Mary Ann, who is a research analyst at Prudential-Bache, bought a house and are now experiencing all of the responsibilities (and headaches) of home ownership. . . . **Chester Hayes** is a field applications engineer at Intel Corp. in Edison, N.J., working exclusively with Bell Labs. He has been dabbling in commodities futures trading as a hobby. Chester reports that **Armen Kasabian** is now practicing medicine at Veterans Hospital in New York City. If anyone has Armen's address, please let me know.

Jeff Rubenstein is working in the family business in Casenovia, N.Y. repairing consumer electronic items, such as stereos, video equipment, and compact disc units. He reports that business is booming and that he gets back to the greater Boston area periodically.

A note from the musical wonder, **Julie Kozaczka**, must be quoted verbatim: "You'll be glad to know that I'm finally working on my lifelong ambition; I took up electric guitar a few years ago and have since co-founded Video Free Europe, a band dedicated to original dance-wave-folk-punk-art-pop. My partners in crime are fellow M.I.T. survivors Scott Griffith, '80 plus *n* (drums and pandemonium), Bob Tillman, '81 (bass), and Keith Sawyer, '82 (Keithboards), as well as our invaluable and long-suffering sound man, Dave Sheppare, '82. We're playing in the usual assortment of Boston clubs and bars, while attempting to home-brew the perfect, definitive extended-play phonograph record. Anyone out there who's into civilized pogo is wildly urged to come see us. Oh, and I still do scanning electron microscopy for a hobby."

I promised you news about class-run (but not sponsored) events. Well, we're still testing the waters, but last Columbus Day weekend about a dozen of us trekked up to Acadia National Park and had an unbelievable time. Up for the trip were **Sue Hanson-Walton** and husband Ray (both of whom are water resource engineers for a firm in suburban D.C.), **Skip** and **Deb Page**, **Dianne Curtis** (who is now working for Lotus Development Corp in Cambridge, makers of Lotus 1-2-3), **Karyn Altman** and buddy Ray Valesquez, sailor-

boy **Al Presser**, **Jim Bidigare**, and my wife Yuko Takagi and me. The trip included hiking, moped-ing (you sneer, but try it; it's fun) and loads of lobster. Ray, Ray and I discovered it is not possible to overdose on lobster—but we tried. We hope to increase the participation in these events and spread them across the country. They're a lot of fun, so try one. In fact, don't wait for us to call you—call us. We're looking for ideas and/or volunteers. Don't be shy.

On the personal front, there's not much news. you've all heard of lawyers chasing ambulances? Well, I've got it backwards—I'm defending almost 100 rate appeals by ambulance companies, and they're chasing me. I'm afraid to get sick in the Boston area. . . . Here's wishing that you all avoid ambulances entirely.—**David S. Browne**, 50 Follen St., Apt. 104, Cambridge, MA 02138, (617) 491-5313

80

I just returned from this year's Havard-Yale game, and am sorry to report that no balloon rose up from the gridiron this year. Also passing with the fall season here in Boston was another Head-of-the-Charles Regatta. I ran into **Liz Fisher, Joan Whitten Miller, Sandy McCarley** and **Kathy Dutrow** at the starting line; I won't comment about the finish. . . . We have a fair bundle of news this time around, thanks to those who wrote it. To begin with, **Thomas Klein** reports that he is doing independent consulting work for young high-tech companies in the Boston area—primarily market analysis and new technology commercialization. . . . **Andrew Guillen** is working in space vehicles engineering at the Aerospace Corp. in Los Angeles. He says he is contemplating a return to grad school as soon as M.I.T. will take him back; in the meantime, the Playboy bunnies are making things "bareable." . . . Congratulations are in order for **Lissa Martinez,** who was recently selected to be the first fellow of the National Academy of Engineering in Washington, D.C. The appointment begins in eary 1984 and will last for about a year.

Back on the east coast is **Linda Jo Dolny McCaffrey**. Recently transferred from Palo Alto, Calif., to the Washington, D.C. office of Systems Control Technology, Inc., she is handling international marketing and implementation of engine management systems. . . . **Diane Gorzyca** is completing her fourth year at Albany Medical College, and is in the process of applying for internship positions in internal medicine, with a geriatrics subspeciality. . . . From **Gerry Mahoney**: "At the end of the summer, I left my job with Rockwell International in Los Angeles to enroll in the M.B.A. program at Columbia University. I've enjoyed the opportunity to catch up with some east coast friends I hadn't seen in a couple of years."

Seth Alford writes, "I got married last May. My wife Rose and I spent the weekends last summer traveling around Oregon. Rose is working on her M.S. in mathematics at Oregon State." . . . From **Matthew Steele:** "I am still living in Tulsa, Okla., which has been quite depressed due to the slump in the oil industry, but is still a very nice city to live in. Since the beginning of 1983, I have been working in Getty's financial planning group, handling the chemical department capital budget, as well as special projects in refining and marketing." . . . **William "Woody" Crane** is still at Bell Laboratories, and just back from a musical expedition in Nigeria. . . . Congratulations are in order for **Kathleen Beauregard Leiterman** and husband, Rich, '79, who became the proud parents of daughter Olivia on September 18, 1983.

What column would be complete without a little foreign correspondence? **Lim Eik** reports that he has just initiated the M.I.T. Club of Singapore (first meeting held in November 1983) and hopes to be able to communicate with the rest of the M.I.T. Clubs. . . . Some "unofficial" tidbits via my informed sources: **Mike Johnson** is back on the east coast, working for Lincoln Laboratories. . . . Joining me at Harvard Business School this year are **Gail Randall, Mitch Gaynor, Charles Malacaria, Hong Nguyen-Phuoung, Phillip Rettger,** and **Dave Ryter**. . . . **Tabetha Frey McCartney** is scheduled to bring a new one into the world in mid-April. One hitch: her finals at Wharton aren't until the beginning of May. . . . Sounds like we're all well on with our lives at this point. Hope to hear from more of you soon.—**Debra A. Utko,** Assistant Secretary, 13A Soldiers Field Pk., Boston, MA 02163

81

Seeing there were as many volunteers to write these notes as there are lava cliff divers, Chuck (who had finals to study for) has graciously allowed me again to report on the goings-on of our class. You really don't know what fun is until you've sat down at the typewriter, reached for a six-pack, and summarized a person two-and-a-half years away from M.I.T. with six words.

Sandra Zack Litwin switched jobs in May and is now a process engineer for Motorola in Mesa, Ariz. She's on the graveyard shift. Sandra's husband, Stuart Litwin, '80, is a device engineer at Motorola. . . . **Rob Firester** is attending medical school at Wayne State in Detroit. . . . While **Rob Schoenberger** has been working as a naval architect, he's really been sticking it to Washington, D.C.: He just won the North Atlantic Fencing Championships in épée. . . . After two years at ATEX **Rich Heller** is now at the Kennedy School of Government. . . . **Mike Savin** is in his third year of medical school and is interested in orthopedic surgery. . . . **Mark McMillen** is working for TRW in San Diego with **Brett Wallach**.

Steel-making, international sales, licensing—sounds like a Playboy centerfold's turn-ons, but that's all **Yannick Belliato** wrote down. . . . "I left DuPont and Houston"—that's what **Bob Davies** did to pursue an M.B.A. at Wharton. . . . **John Maciulewski** is working in the loan department at Connecticut Bank. He's also involved with Solidarity International, which provides assistance to family members of jailed activists in Poland. . . . **Colin Shepard** received his M.S. from Sloan in 1982, and is now the project manager for a commercial development company in suburban Houston. Colin also got married to Jacqueline Reilly (Simmons '83) this past year. . . . "The real world isn't so bad," says **Doug Swanson**; after spending six years at M.I.T., he now works for the National Bank of Detroit. . . . "I live in da Bronx," says **Victor Miller,** who has been working as a systems analyst for L.E.S. . . . **Tony Wilson** will be getting his M.S. in materials engineering from Rensselaer Polytechnic Institute this spring. He and Judy just bought a house and will probably stay in upstate New York for a while. Tony was at the TMS-AIME conference and watched a slightly nervous **Julius Chang** give an excellent presentation. . . . **Bill Shelton** is in Dayton, Ohio, after receiving his M.S. from the Air Force Institute of Technology.

"Still working on exciting stuff" at Microsoft, writes **Steve Hazlerig**. Steve occasionally sees Alice and **Nick Godbey,** Brenda Hawkins, '82, and **John Maloney**. . . . After two years in Paris, **Bob Bechek** is back to start a U.S. subsidiary of A.K.R. Robotics. Bob would like anyone to contact him if they want a blend of French and robotics. He lives now in Livonia, Mich. . . . **Joan Horvath** received her M.S. in fluid mechanics from the University of California—Los Angeles; she will continue on for her engineering degree. Joan also works part-time at the Aerospace Corp. . . . "Life in Cleveland continues to be a thrill," and if you believe that, **Dave Powsner** will sell you some prime real estate in Florida for $100 per acre. Soon Dave will be back in Boston working for a patent law firm.

I spoke with **Wayne Seltzer,** who is enjoying the good life out in Colorado. You know: skiing, rock climbing, sailing, hot tubbing, and, oh yes, working for N.B.I. . . . Meanwhile, I continue to live an uneventful life in suburban Connecticut, sometimes acting in local pubs, but mostly working on remodeling my basement.—**Lew Bender,** substituting for **Chuck Markham,** Secretary, 362 Commonwealth Ave., Apt. 2E, Boston, MA 02115

82

Win Cody is presently developing software on the IBM PC for Traveler's new subsidiary, First Financial Planners. . . . **Stephen Bart** spent a year designing antennas for Martin Marietta Denver Aerospace. He is now back at M.I.T. grad school working with biological processes in the electrical engineering department. (I didn't know there were any biological processes in the EE department!) Stephen says thanks to the Colorado Alumni for his first cross-country skiing adventure. . . . **John LaPlante** received a fellowship from Hughes Aircraft for advanced degree work. . . . **Mike Brody** has begun his first year of study at the New York College of Podiatric Medicine in Manhattan. . . . **Gerard Weatherby** is now at the Naval Submarine Base in Groton, Conn.

Steve Taylor sends tons of news. (First let me issue a disclaimer—I am not responsible for the accuracy or inaccuracy of any news received from Steve.) **Rich Epstein** had been planning to go to Brown Med School, but only a few days before class was due to start, Yale offered him admission. So, as Steve says, Rich is now enjoying life at Yale Club Med. (No grades, no tests-what's not to enjoy? Think of that next time you go to a doctor who graduated from Yale!)

Shawn Sullivan enjoys teaching calculus in the Peace Corps. . . . **John Tenney** is also doing his part to make this world a better place with his stint in the Peace Corps. . . . **George Kraynak**, '81, is back at the Institute and will probably graduate by the time this column is published.

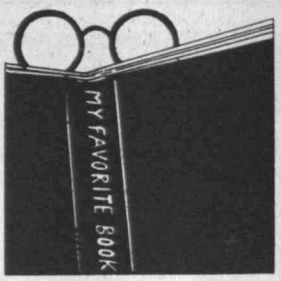
And Steve himself now knows more about the cost/schedule control systems than he ever wanted to know. To keep his sanity (or to regain it), he's started the "Eagle Flight Playhouse." It's called Eagle Flight because you can't hear whenever the F-15's fly overhead. Finally, Steve volunteered to help with the class notes. So, if you want to, you may entrust your life's story to him rather than to me, by writing to his address listed below. If you, too, would like to be an assistant class secretary, just drop me a line. There's no way I'll give up doing the class notes, but perhaps with a little more help, we'll hear from more classmates.—**Rhonda Peck**, Secretary, 38 Bigelow St., Cambridge, MA 02139; **Steve Taylor**, Assistant Secretary, 207 Bartonwood Ct., Niceville, FL 32578

83

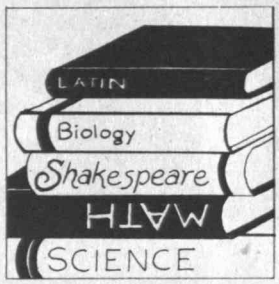
Juris Zagarins writes that he is assistant professor of engineering at Springfield Technical Community College. He is currently living in Springfield with his wife Robin and daughters Sofija and Marija. . . . Hughes Aircraft has selected two members of our class to receive master's fellowships: **David E. Pope** and **Thomas H. Lee**. The fellowships include full tuition, full salary for summer work, prorated salary for work study periods, academic fees and books. Congratulations, Dave and Tom.

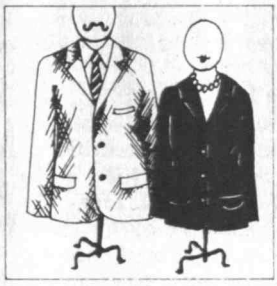
If you can believe it, this is all of the information I have thus far. (I suppose as my column gains more worldwide attention, everyone will begin to write.) I hope to hear from more of you soon.

As for myself, I am still working on my thesis. I managed to save a year of eligibility in track, so I get to compete again this year. I'll try and keep the thesis and the meets in the proper perspective.—**John E. De Rubeis**, Secretary, 86 Mount Vernon St., Boston, MA 02108

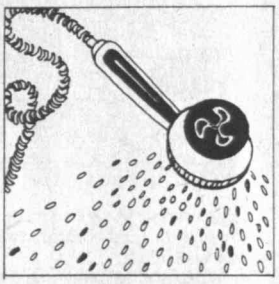


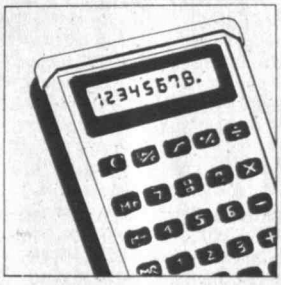
Things for reading, things for packing, things for speeding,

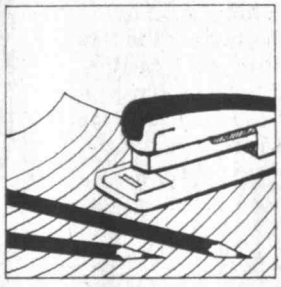




things for cracking. Things for playing, things for dressing,







things for spraying, things for guessing. Things for duty,

and things for soup, things for beauty at

the Coop

founded

in 1882 for undergrads — today we're the largest collegiate store in the world, with over 20 departments open to everyone.

special membership

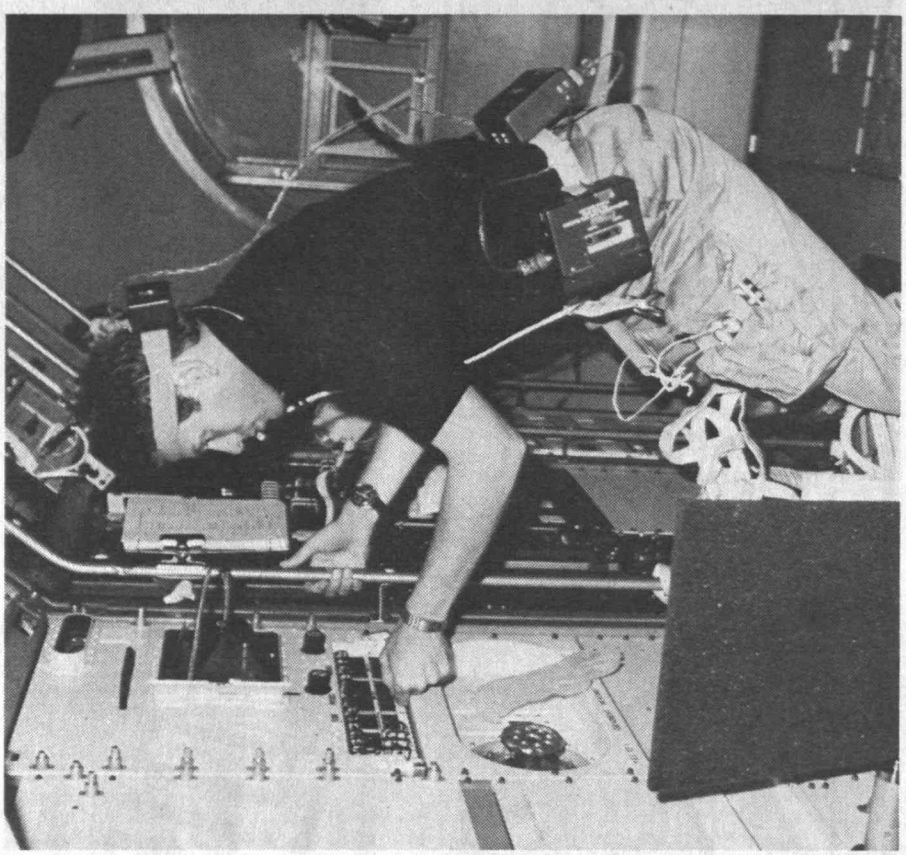
privileges offered to eligible institutions for $1 per year. Apply at the Cashier's desk at any Coop store.

services

include Coop charge, American Express, Mastercard & Visa — mail orders — opticians — typewriter repair — barber shops — personalized stationery — a toll-free telephone service — much, much, more!

M.I.T. Student Center

Courses



NASA

Professor Laurence R. Young, '57, calls the November-December flight of Spacelab I "an enormous scientific success," and one reason was the presence on board of Byron K. Lichtenberg, Sc.D.'79 (right), who's a member of M.I.T.'s Center for Space Research. Lichtenberg and a German colleague, Ulf Merbold of Stuttgart, were the first non-NASA scientists to fly on a U.S. space mission. The photo shows Lichtenberg at the "materials science double rack" facility aboard Spacelab I; the headband is part of an M.I.T. study of space motion sickness for which Professor Young is principal investigator.

I
Civil Engineering

Yupo Chan, Ph.D.'72, former associate professor of engineering at the State University of New York, Stony Brook, has been appointed associate professor in the Department of Civil and Environmental Engineering at Washington State University. . . . **Paul F. Rice,** S.M.'47, reports that he is currently vice-president of engineering at the Concrete Reinforcement Steel Institute, and notes that he is its oldest employee. He is also registered as a civil engineer in Michigan and as a structural engineer in Illinois. . . . **Roy S. Morgan,** S.M.'80, is currently working at Prime Computer, Inc., Natick, Mass., in its Manufacturing Business Systems Division.

Constantine P. Zumpos, S.M.'82, writes that he is pursuing a doctorate program at the School of Civil Engineering at Georgia Institute of Technology with concentration on continuum and computational mechanics and finite element analysis. . . . **George Bugliarello,** Sc.D.'59, president of Polytechnic Institute of New York, was keynote speaker at last fall's 1983 Public Affairs Forum held by the American Association of Engineering Societies in Washington, D.C. His subject: the changing requirements of education to facilitate integrating technical and non-technical issues.

II
Mechanical Engineering

Assistant Professor **James E. Hubbard, Jr.,** '77, a specialist in machine dynamics and vibration control, has received a two-year grant ($30,000 annually) under the IBM Faculty Development Award Program. The grants are intended to enhance the career development of young faculty members working in computer science, materials science, and related fields.

Bharat Bhushan, S.M.'73, advisory engineer with IBM, Tuscon, Ariz., has received three major awards in 1983: the Burt L. Newkirk Award of ASME "for substantial contributions to the field of tribology"; the Achievement Award of IBM's General Products Division "for outstanding individual performance"; and the Norlin Award of the University of Colorado Alumni Association in recognition of outstanding achievements by UC alumni.

The annual Jacob P. Den Hartog Distinguished Educator Award for 1983 was given to one of our own: **Stephen H. Crandall,** Ph.D.'46, who has taught at the Institute in the fields of mechanics, vibration, and acoustics since receiving his doctorate. Crandall "is noted for his devotion to students, his insightful lectures, and his impact upon engineering education," said David N. Wormley, head of the department, in his introduction of Crandall for the Den Hartog Memorial Lecture. The topic: "Rotor Dynamics," a general description of the principles and mechanisms involved in analyzing rotor dynamics.

Bhag C. Jain, Sc.D.'75, served as organizing secretary of the 1983 National Solar Energy Convention of the Solar Energy Society of India, December 16-17 at Vadodara. He is general manager of the Energy Division of Jyoti, Ltd., with headquarters in Vadodara, and in that role he has been responsible for the design, construction, and installation of a number of solar-power installations in India.

Four alumni were honored by the American Society of Mechanical Engineers (ASME) at its 1983 Winter Annual Meeting in Boston:

□ **Iain Finnie,** Sc.D.'53, professor and chairman of the Department of Mechanical Engineering at the University of California, Berkeley, was named honorary member. He was recognized for his "unique contributions to research and practice in the areas of creep, erosion, and fracture of brittle solids and his contributions to engineering education and ASME."

□ **J. Lowen Shearer,** Sc.D.'54, professor of mechanical engineering at Pennsylvania State University, University Park, was awarded the Rufus Oldenburger Medal, to recognize "contributions to the field of fluid control systems, both in teaching and research."

□ **William J. Missimer, Jr.,** '54, delivered the 1983 Henry Robinson Towne Lecture on the management of engineering in business; he is excecutive vice-president of the Pratt and Whitney Group, United Technologies, Hartford, Conn.

□ **John H. Sununu,** Ph.D.'66, governor of New Hampshire (since January 1983), was the ASME's 1983 Roy V. Wright Lecturer. Sununu, a mechanical engineer, educator (he is now on leave from a faculty post at Tufts University), businessman, and community leader, served as a Salem (N.H.) representative in the State Legislature, when he was a member of the Governor's Energy Council. He currently holds membership on the Energy and Environment and the Transportation, Commerce and Technology Committee of the National Governors' Association, and he is the lead governor for aviation.

Malcolm L. Spaulding, S.M.'70, was promoted to professor of ocean engineering at the University of Rhode Island in July 1983. . . . **Robert G. Foster,** S.M.'63, president of Ventrex Laboratories, Inc., Yarmouth, Maine, has been elected to a three-year term to the board of trustees of North Yarmouth Academy.

III
Materials Science and Engineering

Two members of the department at M.I.T. have received two year grants ($30,000 annually) under the IBM Faculty Development Awards Program:

□ Assistant Professor **Terry A. Ring,** who's a specialist in particulate processing of colloids, ceramics, and minerals—especially electronic materials.

□ Assistant Professor **Gary E. Wnek,** whose research centers on polymers for electronic applications.

Donald R. Uhlmann, who joined the M.I.T. fac-

ulty in the field of ceramics in 1965, has been designated to hold a three-year term professorship funded by the Cabot Corp. Foundation, Inc. Uhlmann is a specialist in the structure, properties, and processing of glasses and polymers; his current appointment is professor of ceramics and polymers.

Karl W. Reid, '84, a senior in the department, has been honored with the Monsanto Award, recognizing the black engineering student with the highest academic achievement in the junior year at M.I.T. Reid's record is doubly strong; William D. McLaurin, director of the Office of Minority Education, also applauds him for "unstinting participation in a wide variety of student activities."

Don Ritter, Sc.D.'66, U.S. Representative for Pennsylvania's 15th Congressional District, has been a distinguished life member of the American Society for Metals. The citation notes "contributions to education in metallurgical subjects and governmental concern for metals and materials."

Firoze E. Katrak, Sc.D.'79, has been promoted to vice-president of the Natural Resources Group at Charles River Associates, Boston, consulting on business, economic, and technological issues in the minerals and metals industries for both private and government clients. . . . **Ronald E. Enstrom,** Sc.D.'63, employed with the Display Processing and Manufacturing Research Laboratory at the RCA David Sarnoff Research Center, Princeton, N.J., has been elected a vice-president of The Electrochemical Society. Prior to this appointment, he has served in several capacities within the society, most recently as chairman of the Electronics Division, which focuses on the growth, processing, technology and science of semiconducting materials for electronic device applications.

Seymour L. Blum, Sc.D.'54, has been appointed a member of the Commission on Engineering and Technical Systems of the National Research Council of the National Academy of Sciences. . . . **William S. Coblenz,** reports that he has just accepted a position at the National Bureau of Standards as a ceramic scientist in the Inorganic Chemistry Division.

IV

Architecture

Joan E. Goody of Goody, Clancy, and Associates of Boston has provided endowment for the Marvin E. Goody Prize in Building Arts. The $5,000 award will be offered annually for a thesis proposal that has most promise for advancing the building arts—new uses of materials or methods of construction, a stronger bond between good design and good building, a better link between industry and academe. The prize honors Goody's late husband, **Marvin E. Goody,** M.Arch.'51, who was a member of the M.I.T. staff and faculty from 1953 to 1968 and during that period was founding partner of the firm.

Wayne Andersen, adjunct professor of the history of art, is used to influential clients and major commissions, but this one goes beyond even his norm: he conceived and arranged for the interiors and artwork of the Royal Mosque at Riyadh, Saudi Arabia. It is one of the largest mosques in the world, "one of the greatest art objects in modern times"; and its stained glass is one of the largest such projects in history—more stained glass than in the Gothic cathedrals of Notre Dame, Chartres, and Amiens combined.

John L. Forbis, M.Arch.'65, former consultant for McKinsey and Co., is currently vice-president for strategic planning of the Eaton Corp., Cleveland, Ohio. . . . **Hazel W.S. Wong,** M.Arch.'78, is currently associate and senior designer with Parkin Partnership, architects planners, Toronto, Canada.

Robert R. Ferens, M.Arch.'48, writes, "I recently retired from the University of Oregon after 35 years on the faculty and I am now a professor emeritus in architecture. I am continuing my reading and research into African architecture and planning as well as African arts and crafts. This is in addition to my bicycling, hiking, and traveling, to which I can now devote much more time and energy than ever before. So far it has been a very *active* retirement." . . . **Clark L. Watkins,** M.Arch.'74, reports that he began full-time architectural practice in Palo Alto, Calif., in March 1983, providing services in residential and commercial design.

V

Chemistry

Leo A. Paquette, Ph.D.'59, Kimberly Professor of Chemistry at Ohio State University, is the 1984 winner of the American Chemical Society's $3,000 Award for Creative Work in Synthetic Organic Chemistry, in recognition for his work in reaction mechanisms, synthesis, and the application theory and structure to organic chemistry. Paquette is best known for his synthesis of dodechedrane, the chemical version of dodecahedron, one of the platonic solids. He is the author of over 500 scientific papers, holds 40 patents, and is author of a book on heterocyclic chemistry.

VI

Electrical Engineering and Computer Science

Hermann A. Haus, Elihu Thomson Professor of Electrical Engineering at M.I.T., is the author of *Waves and Fields in Optoelectronics,* a new title in the Prentice-Hall Series in Solid-State Physical Electronics.

Assistant Professor **Shafi Goldwasser,** who joined the department at M.I.T. last fall, is recipient of a two-year grant ($30,000 annually) under IBM's Faculty Development Awards Program. Goldwasser's research interest is in theoretical computer science, encryption, and codes for the computer networks.

Irwin M. Jacobs, Sc.D.'57, chairman of the board, president and chief executive officer of Linkabit Corp., has taken on the additional post of executive vice-president of M/A-COM, Inc., Burlington, Mass., of which Linkabit is a subsidiary. He will remain at his present location in San Diego, Calif. . .

Robert R. Everett, S.M.'43, president and chief executive officer at Mitre Corp., Bedford, Mass., has been awarded the Department of Defense Medal for Distinguished Public Service, its highest recognition of a civilian in peacetime. He was recognized "for exceptionally distinguished public service to the Department of Defense command, control, communications and intelligence community. . . . For more than 30 years, his accomplishments and contributions to the security of the United States have reflected great credit . . ."

Edwin Z. Gabriel, S.M.'51, writes, "Received patent number 4,384,752 (dated May 24, 1983), entitled 'Hook-Up Wires With Magnetic Connectors.' I also received patent number 4,315,320 (dated February 9, 1982) entitled 'Educational Analog Computer Laboratory Manufacturing; covering an educational electronic experimentation lab kit and computer with a 200-page manual that can be sold for $75 each. This lab kit will enable college students to perform some of their electrical and electronic experiments at home." . . . **Thomas Warner,** S.M.'47, reports, "I retired from my position as dean of the School of Engineering at the University of New Haven back in 1976 and have been a professor in the Mechanical Engineering Department since then. Planning a complete retirement sometime in the next year or so. Without M.I.T. I never could have enjoyed the success in life that I've had. My special thanks go to Professors Draper and Den Hartog, who prepared me well for the engineering career I've enjoyed in the field of mechanical vibrations."

Christopher E. Strangio, S.M.'76, reports that he recently licensed an electronic musical instrument patent to Casio (Tokyo, Japan). "I am currently initiating a new venture designing and manufacturing educational computer systems for engineering classrooms and laboratories and am author of two videotape courses distributed by the Center for Advanced Engineering Study at M.I.T." . . . **Elie Baghdady,** Sc.D.'56, is professor of electrical engineering and computer science and associate dean for research and development at Boston University. . . . **Samuel Labate,** S.M.'48, retired in December 1983 as chairman and director of Bolt Beranek and Newman, Inc., Cambridge. . . . **David R. Spencer,** S.M.'68, is president of Data Recording Systems, Inc., of Hauppauge, N.Y., for which initial venture-capital financing was completed last year. Spencer was formerly president and chief executive officer of Muirhead North America, Inc.; he has designed a number of high-performance image scanning, recording, and processing products.

VI-A Program

When this article appears in print, the VI-A Program will be in the process of selecting its 68th class of new students from among the largest number of sophomores ever enrolled in Course VI (380). At the start of the Fall '83 Term VI-A was also at its highest total enrollment of 290 students.

As many readers know from previous articles, the EECS Department has been bursting at its seams for some years. Fall '83 enrollment was 19 percent of M.I.T.'s total enrollment and 37.9 percent of that of the School of Engineering. Undergraduates alone in VI-A make up 47.5 percent of the School of Engineering. The School of Engineering, itself, makes up 50.4 percent of M.I.T.'s total enrollment. It is also interesting to note that the EECS Department is 206 percent larger than the next largest Department (Mechanical) in the Engineering School and is within 16-students of equalling the total enrollment in the School of Science, the next largest school after engineering.

If left unchecked, it is predicted that sophomore enrollment in Course VI could reach 450 to 500 within the next several years. It is not the Institute's plan to allow EECS such a mammoth expansion. The problem before the faculty and administration (*see page A8*) is that the Institute historically has allowed freshmen freedom of choice as to the department of their major.

For about four years now, the department has been trying to get VI-A down to a manageable level of about 250 total undergraduates and graduates. The trend has started, but for some reason the fall '83 projected figure of 262 never got below 290—due in part to some students not finishing their graduate theses when expected.

Belatedly, mention is made of **John H. Craig,** '38, and his visit to the VI-A office. John was here last June to celebrate his 45th reunion. John was chairman of the organizing group which established M.I.T.'s Beta Theta Chapter of Eta Kappa Nu—national honorary electrical engineering society which is still a very active chapter in the department. John served as national president of that association in 1962, during a period when VI-A's director, John A. Tucker, was elected to serve on HKN's national board of directors.

Noted from a write-up in the IEEE Boston Section's *Reflector,* **Vincent W.S. Chan,** '71, was the speaker at a Quantum Electronics and Application chapter meeting. His topic was "Coherent Optical Space Communication Using GaAlAs Lasers." Vincent is currently with M.I.T.'s Lincoln Laboratory.

Keith A. Blanton, '78, tells us he has moved from Houston, Tex., to Atlanta, Ga., where he is working at Georgia Tech's Engineering Experiment Station. . . . One evening **David W. Duehren,** '80, and **Patrick T. Hynes,** '81, both with Teradyne, Inc., Boston, joined John Tucker for dinner and a discussion about setting up businesses. . . . **Daniel G. Jablonski,** '76, visited M.I.T. on behalf of his employer, Naval Surface Weapons Center/White Oak Laboratory, Silver Spring, Md., and talked with Director Tucker about the VI-A Program at NSWC.

Charles A. Kaminski, '70, came in for lunch one day and told us he has joined Instrumentation Laboratory, Lexington, Mass. . . . **Karl A. Nyberg,** '80, writes that he is with Verdix's Westgate Research Park, McLean, Va., and that he has purchased a new home in Vienna, Va. . . . **Kenneth A. Parulski,**

CALVIN CAMPBELL

Department heads who span more than 40 years of the 100-plus-year history of biology at M.I.T. were posed during a centennial symposium program in November: (left to right) Francis O. Schmitt (1941-57), Irwin Sizer (1957-67), Boris Magasanik (1967-77), and Gene M. Brown (1977—)

Life Science in a Technological Environment

After 112 Years Biology Celebrates Its Centennial

They called it the centennial of the Biology Department.

But it wasn't, and it took Professor Bernard S. Gould, '32, whose experience in the department spans more than 50 years, to set the record straight: the first courses in natural history were given at M.I.T. in 1871—zoology, plant science, paleontology, and the like.

What was modestly celebrated last fall with a day-long colloquium and a "centennial dinner" on November 1 and 2 was the 100th anniversary of the arrival at M.I.T. of William T. Sedgwick—in truth a landmark from which stems the modern history of biology at the Institute. For ever since then the department—despite three different names and at least five changes in emphasis—has remained in touch with one basic concept: physics, mathematics, chemistry, and engineering are essential to the solution of biological problems.

Courting Harvard—Unsuccessfully

Sedgwick came to M.I.T. because he was appalled at the low level of preparation then required of their entrants by most medical schools. At the Institute, he thought—with Harvard's distinguished medical school next door—that disgrace could be rectified. But Harvard was unmoved, and Sedgwick soon

Ortega Turns Biology to Policy

While most of M.I.T.'s biology alumni have gone on to top scientific careers, Manuel V. Ortega, Ph.D.'60, has moved toward public service: he's undersecretary for education and technical investigation in Mexico. The daily challenge for his erstwhile colleagues revolves around chromosomes and genes; but Oretega's is different.

The population of Mexico is now 60 million, Ortega told the Biology Department's "centennial dinner" on November 1, and half these people are under the age of 25. Until recent progress in disseminating birth control information, Mexico's birth rate was among the world's highest. The population problem demands a high priority for improvements in food production, health care, and education.

Since Mexico's socialist government decided to apply huge national oil revenues toward the development of educational institutions in 1960, an extensive university and research system has been built. A significant number of the leaders in these institutions are Mexicans educated in the United States and Europe. Dr. Ortega himself served as head of the Center for Research and Advanced Studies at the National Polytechnic Institute from 1978 to 1982, before taking his present job.

The recent retreat of world oil prices has resulted in a huge national debt for the Mexican government, and this debt threatens continued investments in science and education. The task of Dr. Ortega and Mexico's infant educational system is now to reorganize its hastily assembled resources into an efficient tool for national advancement, he told the M.I.T. biology audience.—*Ena Urbach*

turned his attention to water and stream pollution, then a province of chemists. That work led eventually to the formation of the Harvard School of Public Health, with which M.I.T. collaborated until public health became the exclusive province of M.D.s.

Later, Samuel C. Prescott, '94, moved the department toward problems of food and nutrition—so successfully that in 1944 the Department of Food Technology (now the Department of Nutrition and Food Science) was spun off. That was shortly after the arrival of Francis O. Schmitt, with whom began the department's modern era of emphasis on biophysics, molecular and cell biology, and biochemistry.

Since then, said Professor Gould, it has "grown like the 'green bay tree' to eminence"—one of the leading centers in the country for biophysics, microbiology, and genetics. What started out in 2,000 square feet (before Sedgwick came to it the department consisted of a single room 26 x 20 feet, Gould said) now occupies 124,000 square feet. The department's power and leadership are unquestioned.

That eminence reflects the achievements of both faculty and alumni, and a stellar cast of the latter were principal speakers, reporting on their research, during a centennial colloquium on November 2: Carolyn Cohen, Ph.D.'54, professor of biology at Brandeis; Howard M. Goodman, Ph.D.'64, professor of genetics at Harvard Medical School; Leland H. Hartwell, Ph.D.'64, professor of genetics at the University of Washington; Nancy E. Kleckner, Ph.D.'74, associate professor of biochemistry and molecular biology at Harvard; Bernard Moss, Ph.D.'67, head of macromolecular biology at the National Institutes of Health; Robert L. Sinsheimer, '41, chancellor of the University of California at Santa Cruz; and Raymond L. White, Ph.D.'71, professor of genetics at the University of Utah.

A Flow Becomes a Flood

Professor Gene M. Brown, today's department head, had his own tribute to these alumni and his predecessors: his role today is "simply to cash in on an inheritance," he said.

Meanwhile, almost by accident, one of Sedgwick's original aims has also been achieved. In Gould's words, an earlier "gentle flow" of M.I.T. graduates into medical schools has gradually become a "flood"—more than 1,200 in the last ten years, 60 percent of them graduates from the Biology Department.

'79, was at M.I.T. interviewing for Eastman Kodak Co.'s Research Laboratories, Rochester, N.Y., and came to visit John Tucker.

Other visitors signing our VI-A guest book since our last article have been: **Arthur C. Chen,** '61, with General Electric's Research and Development Center, Schenectady, N.Y.; **Charles B. Dietrich,** '77, with RCA Labs, Princeton, N.J.; **Craig E. Goldman,** '80, who is now with Demonics of Cambridge, Mass., and who tells us he was recently married; **Dyung van Le,** '81, with PRIME Computer, Framingham, Mass.; **Steven M. Weiss,** '81, with Hewlett-Packard's Personal Software Division, Sunnyvale, Calif.; and **George B. Yundt,** '80, who's with IMEC Corp., Boston.—John A. Tucker, Director, VI-A Program, M.I.T., Room 38-473, Cambridge, MA 02139

VII

Biology

Two major awards came to members of the faculty at M.I.T. late last year:

□ **Robert A. Weinberg,** professor of biology, shared with Professor J. Michael Bishop of the University of California the Massachusetts General Hospital's Warren Triennial Prize for excellence in medical research. Both winners were cited for "important and innovative contributions to the field of the causation of cancer."

□ **Susumu Tongegawa,** professor of immunology and cell biology, was one of six winners of $15,000 Gairdner Foundation International Awards for his contributions to genetic science.

□ Dr. **Harriet L. Hardy,** who was director of occupational medicine at M.I.T. from 1949 until her retirement in 1979, and has completed her memoirs, now published under the title *Challenging Man-Made Disease* (Praeger Publishers, $24.95). The book records Dr. Hardy's experiences in 40 years dedicated to identifying and fighting work-related health hazards, including beryllium, cadmium, lead, mercury, arsenic, and asbestos.

John M. Keller, Ph.D.'66, professor of biological chemistry at the University of Health Sciences/Chicago Medical School, has been awarded $24,540 by the American Cancer Society to continue for one year at the Max Planck Institute near Munich, West Germany, his ten-year study of how the heparan sulfate molecule is involved in cell adhesion, a process that is lost or altered in malignant transformation and metastasis. . . . **Martin Kahel,** S.M.'53, retired on February 1, 1983, from the Florida Department of Environmental Regulation where he was deputy bureau chief of air pollution control . . . **Clemens E. Prokesch,** S.M.'45, reports, "I am still in full-time practice of internal medicine in New London, Conn. Also I am still president (for my 24th consecutive term) of the Thames Stamp Club here in New London. I am also active in many other philatelic organizations. In addition I am vice-president of the German Club of Eastern Connecticut—a cultural society."

VIII

Physics

The M.I.T. chapter of Sigma Pi Sigma, the national physics honor society, has been cited by the society's national office for its successful growth in the first year since its founding. Members now number over 100, making M.I.T.'s one of the few chapters to reach this size so quickly. Professor **June L. Matthews,** who's on leave this year to teach physics at Carleton College, her alma mater, is SPS adviser at M.I.T.

Professor **Jeffrey Goldstone,** known for contributions to the theory of nuclear structure and elementary particles, is now the Cecil and Ida Green Professor. Goldstone, who is director of the Center for Theoretical Physics, joined the M.I.T. faculty in 1977.

Robert N. Noyce, Ph.D.'53, vice-chairman and co-founder of Intel Corp., was guest of honor at the Exploratorium, San Francisco, on November 16 to receive the museum's annual award. Professor **Philip Morrison** was guest speaker at the gala event.

Energy in Atomic Physics is the title of a new book by **R. Bruce Lindsay,** '24 (New York: Scientific and Academic Editions, Van Nostrand Reinhold Co., Inc., 1983, $45).

James F. DeBroux, S.M.'79, has been since July 1982 instructor in the Department of Physics at the United States Military Academy, West Point, N.Y.

IX

Psychology

The Ralph W. Gerard Prize of the Society for Neurosciences was given late last year to Institute Professor **Walle J.H. Nauta,** recognizing his position as one of the world's leading authorities on the anatomy of the human brain.

X

Chemical Engineering

M.I.T. and its alumni had prominent parts in the 75th anniversary celebration of AIChE in Washington late last year. Of 30 AIChE members honored as "eminent chemical engineers," nine are members of the Institute community:

□ **Manson Benedict,** Ph.D.'35, professor emeritus of nuclear engineering—"one of America's most renowned nuclear engineers."

□ **W. Kenneth Davis,** '40, of Bechtel Corp.—". . . a long and distinguished career in academia, government, and industry."

□ **Thomas B. Drew,** '23, professor emeritus of chemical engineering—". . . a long and distinguished career in chemical engineering, especially in the field of heat transfer."

□ **Hoyt C. Hottel,** '24, professor emeritus of chemical engineering—"the world's foremost expert on combustion heat transfer."

□ **Arthur E. Humphrey,** S.M.'60, provost and academic vice-president of Lehigh University—". . . a long and distinguished career in the field of biochemical engineering and biotechnology."

□ **Ralph Landau,** Sc.D.'41, chairman of the board of Listowel, Inc.—". . . major contributions to organic chemical technology."

□ **Jerry McAfee,** Sc.D.'40, chairman and chief executive officer of Gulf Oil Corp.—". . . a distinguished industrial career."

□ **Arthur B. Metzer,** Sc.D.'51, professor of chemical engineering at the University of Delaware—". . . a leader in research on fluid mechanics."

□ **James Wei,** Sc.D.'55, head of the Department of Chemical Engineering at M.I.T.—"an expert in catalysis, reaction engineering, and air pollution control."

At the same meeting, two members of the M.I.T. faculty received major awards:

□ **Charles L. Cooney,** Ph.D.'70, the Food, Pharmaceutical and Bioengineering Division Award.

□ **Edward W. Merrill,** Sc.D.'47, the Alpha Chi Sigma Award for research in biomedical engineering and polymers.

And AIChE Founder's Awards were given to three M.I.T. alumni: **W. Kenneth Davis,** '40, **Margaret Hutchinson Rousseau,** Sc.D.'37, and **Robert B. MacMullin,** '19. Ms. Rousseau was cited as the first woman member of AIChE and the first to be awarded a doctorate in the field from M.I.T.

Albert S. Humphrey, S.M.'49, writes from London that 1983 was a professional "break-through" year for his firm, Business Planning and Development. The company expanded into Benelux, acquiring an office building in Antwerp that will be occupied by February 1984, and conducted a number of successful training programs for both old and new clients. Mr. Humphrey himself was named a visiting lecturer at the Newcastle Polytechnique Business School.

G. W. Nichols

New Englander of 1983

Two new energy facilities yet to be sited are needed if the recent trend toward lower energy prices in New England is to be continued, says Guy W. Nichols, S.M.'61, chairman, president, and chief executive officer of the New England Electric System:

□ A gas pipeline reaching northeast from New England, to newly discovered gas fields off the Canadian Maritime Provinces.

□ Additional long-distance electric transmission lines to Quebec and New York State—the former to tap surplus hydroelectric power in eastern Canada, the latter surplus coal-fired capacity in Pennsylvania and the midwest.

New England now pays just over 20 percent more than the U.S. average for electricity, says Nichols; that's down from 41 percent only a decade ago—a tribute, he says, to coal conversion by New England utilities and conservation by New England customers.

Nichols' remarks were made at a dinner in his honor as the New England Council's New Englander of 1983. The award is made annually for contributions to improving the region's economy, social welfare, or quality of life. Nichols was a Sloan Fellow at M.I.T. in 1960-61.

Joe Mauk Smith, Sc.D.'43, professor of chemical engineering at the University of California, Davis, received the 1983 Warren K. Lewis Award of the American Institute of Chemical Engineers at AIChE's fall meeting in New York. The citation was for "his outstanding accomplishments as an educator, researcher, textbook writer, and academic administrator." Some of his accomplishments: author of 270 technical papers, author or co-author of two textbooks, guest lecturer at several universities worldwide, and five Fulbright Awards . . . . **Robert C. Gunness,** Sc.D.'34, former vice chairman and president of Standard Oil Co. (Indiana), has recently retired as director of the Consolidated Foods Corp., Chicago. . . . **Donald M. Leslie,** S.M.'39, writes that he and his wife Mabel "are enjoying retirement in Aptos, Calif., a scenic spot on Monterey Bay. My activities consist primarily of senior citizen volunteer activities, traveling, gentleman farming, and entertaining friends." . . . **Robert C. St. John,** S.M.'47, retired on February 1, 1983, as director of process technology for Emery Industries, a division of National Distillers and Chemical Corp. He began with Emery as a chemical engineer on January 1, 1949.

Edwin H. McCormick, S.M.'32, lists his latest activities: "superintendent of Jekyll Island Water and Wastewater Departments; holder of Georgia certification: Class I operator wastewater and class II laboratory technician wastewater, class II operator groundwater, and class III laboratory technician water; director of the Southeast Georgia Division, Georgia Water and Pollution Control Association; past president of Jekyll Island Lions Club; organizer and past president of Jekyll Island Men's Golf Association; treasurer of the Mozart Society of Glynn County; and past president of Jekyll Island Art Association. All of this after retirement."

Stephen C. Dodd, S.M.'76, writes, "I would like to announce the birth of my third child, Jeffrey, on September 23, 1983. Baby is doing fine, so are mother and father—but we could use a bit more sleep! I have been promoted to assistant vice-president of research and development of the Davey Co., Jersey City, N.J., and was elected to the board of directors last April." Dodd would welcome word from classmates at 613 Municipal Drive, Thorndale, Penn. 19372.

William J. LaPoint, Jr., '84, has won a $1,000 tuition-assistance grant in the American Consulting Engineers Council's National Scholarship Awards competition. In addition to his chemical engineering major, LaPoint is a research assistant in the Fuels Research Laboratory, working under a UROP grant on polycyclic aromatic hydrocarbons produced in combustion.

Professor **Adel F. Sarofim,** Sc.D.'62, of the department at M.I.T. and **Edward A. Mason,** Sc.D.'50, vice-president—research at Standard Oil Co. (Indiana), are members of the Energy Engineering Board of the National Research Council/ National Academy of Sciences Commission on Engineering and Technical Systems.

David Hacker, S.M.'50, writes, "Left the University of Illinois College of Engineering in 1981 and joined the Avco Chemical Corp.'s Research Center, Naperville, Ill. I am a member of the research staff on olefins production and development, currently engaged in new technology for separations. My daugher Karen graduated from Northwestern Medical School in 1983 and is now a resident in medicine at Boston City Hospital, and my daughter Julie is a graduate student in architecture at the University of Illinois." . . . **William E. Tucker, Jr.,** S.M.'42, has retired from the post of chairman and chief executive officer of Caltex Petroleum Corp., Dallas, Tex. . . . **Stephen C. Dodd,** S.M.'76, writes, "My wife, Margaret, and I have lived in Thorndale, Penn., for over two years now and I am still the assistant plant manager for the Davet Co., but am devoting more time to process research and development. I spent a weekend with **Graham Woerner,** S.M.'76, last July in Woodstock, Conn."

Bazie Karim, S.M.'49, reports that he has been appointed as Secretary to the Government of India in the Cabinet Secretariat, in charge of economic coordination. The position is the highest post to which a government civil servant can aspire, and Karim states that he owes a lot of his success in life to his graduate training at M.I.T. Prior to taking his present post, Karim was for 10 years in private industry, for 5 years in the Indian government's Bureau of Public Enterprises, and for 3 years (1979-1982) assistant executive director of the International Centre for Public Enterprises, Ljubljana, Yugoslavia.

XI

Urban Studies and Planning

Melvin H. King, adjunct professor at M.I.T. who is director of the Community Fellows Program, has returned to work at the Institute following an unsuccessful campaign for mayor of Boston. King claimed the number-two spot in the preliminary election in early fall, thus becoming the first black to be a serious mayoral candidate in the city. But his campaign as the candidate of a "rainbow coalition" of black, Hispanic, and white people fell short in November.

XIII

Ocean Engineering

Captain **Harry E. Davis,** U.S.N., S.M.'42, sends a cryptic report from Lake Placid, N.Y.: "retired." He was last (1980) reported as working for the administrative center for the XIII Olympic Winter Games. . . . **John C. Scalzo,** S.M.'73, is currently in the United States Navy, stationed at Commander Naval Air Forces, Atlantic Fleet. . . . **Lawrence L. Laine,** S.M.'67, is presently working on his Ph.D. in electrical engineering at Old Dominion University, Norfolk, Va.

XIV

Economics

Professors Paul L. Jaskow and Richard Schmalensee, '65, are co-authors of *Markets for Power: An Analysis of Electric Utility Regulation* (M.I.T. Press, 1983, $19.95). The book analyzes four generic proposals for allowing free market forces to replace government regulation in the electric power industry.

Margaret DeVries, Ph.D.'46, reports, "My latest volumes on the history of *The International Monetary Fund* (IMF), covering the years 1972 to 1978, is now in the final stages of preparation. These three new volumes will bring to eight the volumes of IMF history that I have authored or co-authored." . . . **Jeffrey A. Dubin,** Ph.D.'82, is currently assistant professor of economics at the California Institute of Technology.

XV

Management

The new J.S. Kieckhefer Career Development Professorship in Technological Assessment in Health Care has been assigned to Dr. **Stan N. Finkelstein,** associate professsor of health management in the Sloan School. The professorship, funded by the Kieckhefer Foundation of Prescott, Ariz., is assigned to the Harvard-M.I.T. Division of Health Science and Technology; its purpose is to help increase understanding of the effects on health care of new biomaterials, diagnostic instruments and techniques, treatment procedures, and delivery and payment systems.

Lesley E. Markman, S.M.'72, reports that she is director of product development for the Cortex Corp., Wellesley, Mass.; she was married last year to Diego Gonzalez, and they are expecting their first child this spring. . . . **Ernesto J. Poza-Varre,** S.M.'74, executive editor of *Industry Week* had a feature story on strategic management practice in its October 17, 1983, edition. Also, his article, "Twelve Actions to Strong U.S. Factories," a productivity strategy study, was published in the fall, 1983, issue of *Sloan Management Review*. . . . **Robert J. Martel,** S.M.'66, president of Robert J. Martel Associates who is adjunct professor at the College for Financial Planning of the University of Massachusetts, Boston, has been elected to the National Board of Directors of the International Association for Financial Planning. . . . **Thomas R. Williams,** S.M.'54, chairman of the First Atlanta Corp., has joined the Board of Directors of Bell South Corp., Atlanta. . . . **Richard H. Grueter,** S.M.'78, was promoted to audit manager at Price Waterhouse, Boston, in April 1983. . . . **Donald L. Barefoot,** S.M.'78, writes, "I recently took a job with Camco, a division of Emerson Electric, Chicago, Ill. My new position is vice-president of manufacturing."

Sloan Fellows

Wayne J. Holman, S.M.'39, has been awarded the 1983 Bronze Beaver by the M.I.T. Alumni Association. In part, his citation read: "Over the decades Jack Holman has expressed ongoing concern and provided unstinting support to the efforts of the Sloan School and the Institute. . . . He served as the first president of the Society of Sloan Fellows and indeed was one of its founders; and he successfully led an effort to endow a professorship in honor of the late Alfred P. Sloan, Jr." . . . **William O. McCoy,** S.M.'68, former vice chairman of South Central Bell Telephone, has become vice chairman and director of the Bell South Corp., Atlanta, Ga. . .

Frank Perna, Jr., S.M.'70, former vice-president of Bell & Howell Co., is currently corporate vice-president and group executive, Technical Products Group of the Whittaker Corp., Los Angeles, Calif. . . . **Carl H. Janzen,** S.M.'74, vice-president and group executive at Burroughs Corp., Detroit, Mich., is resigning from this position "for personal reasons."

William R. Thompson, S.M.'75, is currently president/general manager of the Field Service Division at Western Union Telegraph Co. . . . **Albert T. Camp,** S.M.'56, reports, "Retired from senior executive service in the Navy in 1980 and presently consult for Morton Thiokol, Inc., VSE Corp., and a Belgium firm to keep up in my field of weapons propulsion. In 1977 we established a small plant on our farm to process, bottle, and distribute Grade A goat milk. We are the sole suppliers to the greater Washington/Baltimore metro area. Overall, this operation is a challenging management enterprise, especially for a chemical engineer with a Sloan Fellow experience. There are less than one dozen comparable, integrated goat and dairy enterprises in the United States. The need for goat milk exceeds the demand generally—essential for people allergic to cow milk."

Gerhard H. Schulmeyer, S.M.'74, is currently assistant general manager and corporate vice-president of Motorola, Inc., Schaumburg, Ill. . . . **Alexander R. Lehmann,** S.M.'68, former president of A.R. Lehmann & Co., is presently vice-president of investor relations at IC Industries, Inc., Chicago, Ill. . . . **David S. Gould,** S.M.'64, has been promoted from vice-president to executive vice-president of Caterpillar Tractor Co., Peoria, Ill.

John O. Grettenberger, S.M.'73, director of the General Motors Corp. European operations, is now also director of product, strategic and business planning for the Oldsmobile Division, Lansing, Mich. . . **Keith K. Kappmeyer,** S.M.'69, director—research, steel at United States Steel Corp., Pittsburgh, Penn., has been promoted to vice-president—technology, steel and related resources. He joined U.S. Steel in 1957 and has held a variety of posts in process metallurgy.

Senior Executives

George R. Armstrong, '66, retired on November 1, 1982 as executive vice-president of Caterpillar Tractor Co., Peoria, Ill. . . . **Benjamin K. Sollars,** '58, has retired as president of Diamond Chain Co., Indianapolis, after 37 years of service. Sollars joined the firm in 1946 as a junior engineer, became plant engineer in 1950, factory manager in 1956, vice-president in 1958, assistant general manager in 1960, and president in 1962. . . . **Charles A. Wentz, Jr.,** '75, recently became president of Ensco, Inc., El Dorado, Ark. Ensco is the industry leader in hazardous and PCB waste incineration. . . . **David S. Hollingsworth,** '70, former vice-president of planning for Hercules, Inc., Wilmington, Del., has become the firm's vice-president of marketing.

Management of Technology Program

Charles A. Berry, S.M.'83, was promoted at Pilkington Brothers, England, last November. He is now new business development director for the Electro-Optics Division. He and Irene soon will move to St. Asaph in North Wales. He says his new position should bring him to the United States fairly often, so we are looking forward to a visit soon. . . **Elliot S. Blackman,** S.M.'82, has taken a position with Digital Equipment as an engineering manager. He is in their Hudson, Mass., location and reports that he is the first of a new applications group that will grow to six to seven people. . . . **Julian Nikolchev,** S.M.'83, has recently been promoted at SRI International to be manager of a new program in the area of technology management. He spent ten days in Japan in October and is planning a trip to England. Julian reports that Betsy is fine, staying home these days with Alexandria, and that Alexandria is growing up very fast and is almost walking.—Jane Morse, Program Manager, M.I.T., Room E52-125, Cambridge, MA 02139

XVI

Aeronautics and Astronautics

Robert C. Seamans, Jr., S.M.'42, professor of environment and public policy at M.I.T., is now director of the Pneumo Corp., Boston. . . . **Donald J. Kutyna,** S.M.'65, is director of the Air Force Space Shuttle Program. This includes Vandenberg Air Force Base, the west coast launch site; the inertial upper stage space booster program; the Consolidated Space Operations Center; the Air Force satellite tracking network; and all Air Force expendable launch vehicles: Titans, Atlas's and Thors. . . . All this on a 'C' in 6:02 and 6:03," says Kutyna. . . **Francis J. Hale,** Sc.D.'63, who teaches at North Carolina State University, Raleigh, reports that he has coauthored (with J.S. Doolittle) *Thermodynamics For Engineers,* published by John Wiley and Sons, 1983. The SI edition to be released in 1984. He has also written *Introduction to Aircraft Performance, Selection, and Design,* published by John Wiley and Sons, scheduled for release in early 1984.

Samuel F. Powell III, S.M. '57, has been appointed the new technical director of the Coast Guard Research and Development Center, Groton, Conn., serving as principal adviser to the center's Commanding Officer and as director of the Center in the CO's absence, as well as providing scientific, technical, and managerial leadership. Formerly he was with the National Highway Traffic Safety Administration to the Coast Guard. . . . **John R. Monk,** S.M. '57, writes, "I am an aerodynamics specialist with the Boeing Aerospace Co. on the SRAM Program." . . .**Efrem G. Mallach,** Ph.D. '69, has been appointed general manager of Northeast Division of General Systems Group, Inc., Salem, N.H., responsible for directing marketing and technical activities for the New England, New York, and New Jersey areas. . . . **Oktay Yesil,** S.M. '70, is currently a specialist engineer at the Boeing Commercial Airplane Co. . . . **Miller A. Wachs,** S.M. '35, reports, "After six years with Lycoming Motors and 32 years with Sikorsky Aircraft, I am continuing to practice engineering as a self-employed engineering consultant."

XVII

Political Science

A grant of $63,000 from the Spencer Foundation has come to Professor **Michael Lipsky,** who will use it to study teacher training programs in Massachusetts and elsewhere—especially how schools and practicing teachers interchange with educational programs.

XVIII

Mathematics

Denis W. Loring, S.M.'71, writes, "I'm now vice-president and actuary at Equitable Life Assurance Society in New York, with responsibility for all reinsurance operations. My wife Paula (RPI '68) and I are living on the upper west side and loving it."

XIX

Meteorology

Henry N. Lorenz, Sc.D.'48, professor of meteorology at M.I.T., and **Henry Stommel** of the Woods Hole Oceanographic Institution share the distinction of the Crafoord Prize of the Royal Swedish Academy of Sciences for 1983. They are cited "for fundamental contributions to geophysical hydrodyanmics," contributing to "a deeper understanding of the large-scale motions of the atmosphere and the sea."

XXI

Humanities

Kenneth R. Manning, associate professor of the history of science in the Program in Science, Technology, and Society, is the author of *Black Apollo of Sciences: The Life of Enrest Everett Just* (New York: Oxford University Press). Just, born in 1883, taught at Howard University and did pioneering work in cell biology there and at the Marine Biological Laboratory, Woods Hole. Professor Stephen Jay Gould of Harvard calls Manning's "the best book I have read this year," and "among the first biographies I have ever read" in a lead review in the *New York Review of Books.*

The Fish People, an account of an unusual network of local communities in the northeast Amazon Valley, has been published for **Jean E. Jackson,** associate professor of anthropology, by Cambridge University Press.

XXII

Nuclear Engineering

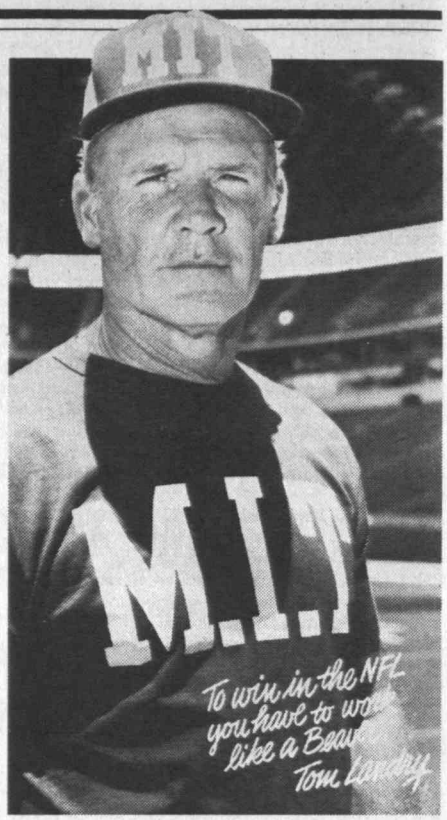
John K. Buckner, S.M.'60, former chief financial officer and acting chief executive officer for Prime Computer Corp., is now chief financial officer and senior vice-president of EG&G, Inc., Wellesley, Mass. . . . Two alumni report in from Chile: **Eduardo Testart,** S.M.'81, writes, "At present I am the head of the Safety Department at the Chilian Nuclear Energy Commission. The department is composed of an assessment group, an inspection enforcement group, a licensing group, and an environmental control group." And **Christian Schmidt,** S.M.'76, reports that he is currently technical adviser to the Joint Chief of Staff of the Chilean Armed Forces; professor of nuclear engineering of Universidad Catolica de Chile; and adviser to the chief of naval operations for technical legislation.

George Yadigaroglu, Sc.D.'70, reports that on October 1, 1982 he was appointed professor and head of nuclear engineering at the Swiss Federal Institute of Technology (ETH), Zurich, Switzerland. He was previously professor at the department of nuclear engineering at the University of California, Berkeley, and from 1979 until 1982 he was head of the Nuclear Regulatory Service of the Greek Atomic Energy Commission in Athens.

Technology and Policy Program

Philip A. Lorang, S.M.'77, has been promoted to chief of the technical support staff for the Emission Control Division of the Environmental Protection Agency, Ann Arbor, Mich. . . . **Steve Pinkerton,** S.M.'82, has been promoted to general manager of Second Wind, Somerville, Mass., an electronics manufacturer for the wind industry. . . . **Thomas Lot,** S.M.'83, has been assigned to officer training at St. Cyr, the French military academy.—Richard de Neufville, Chairman, Technology and Policy Program, Room 1-138, M.I.T., Cambridge, MA 02139

Under the Domes



"With affection and respect," the M.I.T. Athletic Board enacted a "resolution of appreciation" to Clint W. Murchison, Jr., '44, late last spring. Last fall came a unique "thank you" from the owner of the Dallas Cowboys: color prints of this picture of the Cowboys' Tom Landry in the uniform of an M.I.T. coach. Murchison was chairman of the sponsoring committee for the new Athletic Center, and he's been a long-time generous supporter of M.I.T. athletics.

Gray: Donors' Scales too Low

M.I.T's most urgent financial need is for student aid funds—scholarships and loans, President Paul E. Gray, '54, told the Corporation Development Committee last fall.

More than half of last year's undergraduates required financial aid to meet their bills, which averaged $15,000 for the year at M.I.T. To meet that need the Institute awarded about $8 million in scholarships, and half of that—$4 million—came from unrestricted funds.

This year unrestricted funds will be tapped for nearly $5 million. Student aid is "the fastest growing element in the unrestricted funds budget," President Gray said.

Other current goals listed by President Gray for CDC members:

☐ Endowed professorships. Good progress in narrowing the gap between faculty and industrial salaries recently, said President Gray, but there remain only 150 endowed chairs for a faculty of over 1,000—"short of the mark set by peer schools."

☐ Independent research funds. The best example of what's needed is what we have, said President Gray—the Sloan Research Fund in the physical sciences. It provides more than $1.5 million a year for exploratory research in new fields not yet mature enough for major industrial or government support. Similar funds are needed in other fields, especially management, the humanities, social sciences.

☐ Unrestricted funds. These are "our most important means of flexible, quick responses to unexpected educational and research opportunities," said President Gray, and M.I.T. could use twice as much as it now receives.

Special project needs include $15 million for Project Athena, $3 million for a VLSI center now under construction, $5 million to complete funding for the arts and media technology center, also under construction, $2 million to cover the cost of new undergraduate chemistry laboratories completed last summer, $3.5 million for a new Center for Engineering Design, and $1 million a year to cover operations of the UROP program and new programs in the Whitaker College.

The basic problem, President Gray told his CDC audience: "Donors' sense of scale is growing at a rate far less than the cost of what we need."

CALVIN CAMPBELL

Nine officers of M.I.T.'s first sorority, Alpha Phi, posed last spring. Left to right: (front) Ann E. Classen, '84, Pamela M. Gannon, '84, Kathleen A. Harrington, '84, and Kristin A. Dinsmore, '85; (rear) Diane M. Peterson, '84, Christine J. Woelfel, '85, Deborah Goldfarb, '83, Julie M. Tiao, '83, and Pauline Liu, '85.

Sorority On the Way

The first social sorority at M.I.T. is one step closer to official status as a chapter: Alpha Phi, holding its first "rush" last fall, pledged 31 co-eds out of 33 invited, giving the group a total membership of 65. That gives it the weight of members needed to achieve official "chapter" status from Alpha Phi's national office in February, and the search for a house—and financing to purchase it—continues.

The New Orchestra of Boston

The increasing quality of musicians at M.I.T. and their professional recognition as members of the M.I.T. Symphony Orchestra have prompted Professor David Epstein, its director, to organize a second orchestra—fully professional—in residence at the Institute.

The 45-piece New Orchestra of Boston has as its core what Epstein calls "the remarkable group of players . . . of professional caliber who are part of the M.I.T. community and . . . who would like to function at their highest capacity." Four are students, four alumni, and eight staff—including members of the Music Section in the School of Humanities and Social Sciences. To that core have been added three former members of the M.I.T. Symphony Orchestra and a number of professional musicians from Greater Boston.

A private debut concert is scheduled for February 18 at the American Academy of Arts and Sciences. There will be a public debut on March 20 in Kresge Auditorium and an appearance at Alice Tully Hall of Lincoln Center, New York, on March 27. And the New Orchestra of Boston will be in residence at the Mozarteum, Salzburg, Germany, for its 1984 International Summer Course.

Hope Leaves; Small Squall Ensues

Mary O. Hope, for 11 years assistant dean for student affairs at M.I.T., resigned from that post late last year, and her departure precipitated concern from the Black Alumni of M.I.T. (BAMIT) and a number of students. The action "shocked and dismayed members of BAMIT," wrote Michael E. Fant, '73, and Reginald Van Lee, '79, president and secretary, respectively, of the organization.

President Gray, pressed by *The Tech*, expressed confidence in Shirley McBay, dean for student affairs, on the issue, saying that the case was "handled fairly, . . . in a manner consonant with the Institute's policies." He and members of the dean's office declined to respond "to questions of detail," nor did Hope do so.

Simplex Developer Signs In

The Institute's long search for users for the "Simplex property," the 25 acres northwest of the campus formerly owned by the Simplex Wire and Cable Co., may be ending. Final papers have now been signed with

Continued on page A26

Diana ben-Aaron

Continued from page A2

for cleaning wires, eventually fell by the wayside, prey to the tension between the two principal researchers and their disparate working methods. Postdoctoral researcher Stuart Cogan appeared to breeze through life on his wits and his luck; he seemed to have a "magic touch" with everything from machinery to paperwork. His sidekick, J.D. Klein, the senior graduate student, had depended for his success on hard work and methodical application. J.D. was studying long hours for his doctoral exams, occasionally breaking the monotony by making a few hundred precise, painstaking measurements or repairing some equipment.

This difference of approach caused bitter disagreements about laboratory methods and how best to direct the UROP students, of which I was one. I would ask whether or not to clean the wires and Dr. Cogan would say airily, "Oh, don't bother, it never made a bit of difference anyway."

Across the room, J.D. would glare at this defiler of scientific caution. "But Stuart," he'd say disgustedly. "That's *tacky*."

We converted batches of copper-niobium wires into superconducting wires, and every so often we tested them as superconductors in the powerful magnetic fields at the Francis Bitter National Magnet Laboratory. The graduate and postgraduate students churned out measurements, drew conclusions, and even published a few more papers, but they made no tangible progress toward a marketable product or even a coherent theory of how the different kinds of bronze affected superconductors. No one else appeared to mind this.

Now and then, we would participate in conferences with the National Magnet Laboratory's Superconducting Materials Group. They were trying to make similar wires using a different process and were not much closer to a foolproof formula.

From Niobium to Ice Cream

Summer turned to fall, and I started an experiment of my own directed at reducing Kirkendall porosity. Still no fusion reactor or high-speed trains had appeared in the lab. Instead, a much more immediate application for our machine shop had been found.

I walked in one October evening to find Dr. Cogan and J.D. scrutinizing an oddly-shaped piece of metal and half a wooden barrel.

"What's this?" I asked.

"It's an ice-cream machine," chortled J.D. "Stuart's gonna make us all ice cream."

"Right," I said, dismissing it as J.D.'s idea of a witticism.

But no, he had been serious. Dr. Cogan had indeed built an ice-cream machine for Toscanini's, a local homemade ice-cream parlor, on his own time. The store's owners needed another machine for a branch they were planning to open in South Carolina. The only readily available models were distributed by Steve's, a rival ice-cream purveyor that demanded not only an extortionate base price but also cuts of the future profits from all ice cream made in their machines.

Dr. Cogan had undertaken to compete with Steve's, forming a concern called the Penguin Ice-Cream Freezer Co. and hiring J.D. as a consultant. Whether he had secured the contract on the basis of his mechanical ability or his knowledge of low-temperature physical chemistry was open to question.

Midway through the spring, I finished my simple experiment and began to spend confused hours trying to make sense of the results.

Dr. Cogan's analysis of my experiment was long and detailed. It ended with a conclusion: "Clearly if we just keep the wires at 500° Celsius for long enough, we can get rid of all the porosity." I asked approximately how long "long enough" meant. "A few weeks," said Dr. Cogan.

"But," I protested, "I thought the point of our research was to come up with short, simple, and cheap heat treatments that would appeal to industry."

Dr. Cogan thought a moment. "To tell you the truth," he said finally, "I'm not sure what the purpose of our research is anymore." He thought some more. "It's keeping the Department of Energy happy, I guess."

Aghast at such a casual purpose in view of the amount of work we were putting in (not to mention the highly directed environment around us), I decided it was time to leave, so I devoted most of my free time for the remainder of the term to finding another job for the approaching summer.

The last time I saw anyone from the lab was when I ran into Dr. Cogan at Commencement. I tried to explain my reasons for leaving. "I'm eighteen years old," I said, "and I still don't know what I want to do with the rest of my life."

"That's all right" said Dr. Cogan reassuringly. "I'm thirty years old and I still don't know what I want to do with the rest of my life."

Zoom Before the Experts

Continued from page A11

not to. Introduced in 1981, "Demon" will be responsible for half of Zoom's 1983-84 sales.

"Hot Shot," Zoom's third entry in the telecommunications products market, is an automatic dialer designed to give easy access to the many different long-distance telephone networks now available. The next product will be a modem especially designed for IBM personal computers, due later this year. In a field that will by then be highly competitive, Zoom's modem will be outstanding for its low cost (about $125) and ease of use—"Take it home and plug it in," Manning says.

All these products are made for Zoom by subcontractors, all in the U.S.—because "we like the ease of control and flexibility of domestic manufacture," Manning told the Enterprise Forum. Most of Zoom's products are jobbed to retailers, with private brands applied to some; Radio Shack is the largest single customer. Zoom's staff includes 45 engineers, 11 of them M.I.T. alumni.

No Financial Guru

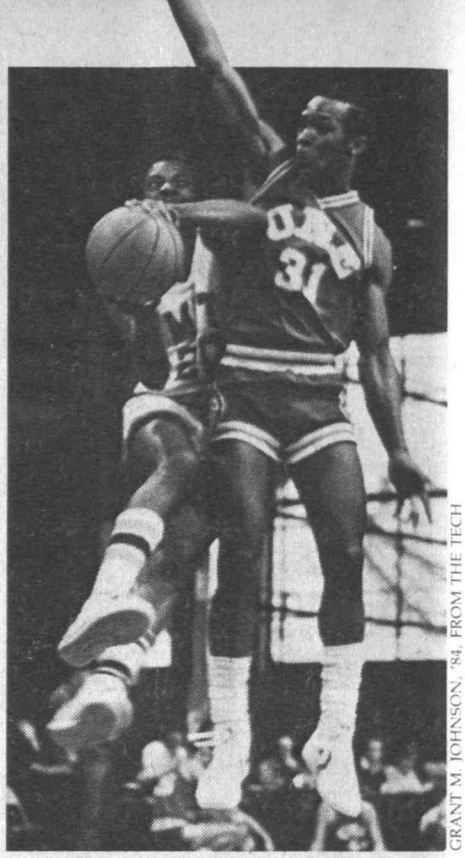
All four of Zoom's advisers on the Enterprise Forum panel agreed that the company shows "a remarkable combination of technical and marketing skills"—the words of William J. Hecht, '61, former manager of human resources at Watters Associates (he is now executive vice-president of the M.I.T. Alumni Association). But all thought the company was unprepared for the risky new phase it is entering—lots of competition and reliance on manufacturers over which it has minimal control.

Robert J. Crowley, portfolio manager at the Massachusetts Technology Development Corp., says Zoom is "a clear case of undercapitalization." And that's an especially chancey situation, he said, because "there is no resident financial guru in this company."

But even with that financial expertise in place, Zoom may not easily attract the new captial it needs. It's in a high-volume, low-sales-price business that will be increasingly competitive, and prices will "inevitably" come down, said Albert Paladino, '62, partner in Advanced Technology Ventures, Inc.

"Why do you think you can make it?" asked a member of the audience.

Because we have "confidence in our products and the people who work on them," said Manning, pointing with pride that the audience understood and shared to the chart of Zoom's five-year sales growth.



GRANT M. JOHNSON, '84, FROM THE TECH

In early-season basketball, Randall Nelson, '86, struggles to launch a shot from under the screen of a University of New England guard. M.I.T. lost, 77-60.

Under the Domes

Continued from page A25

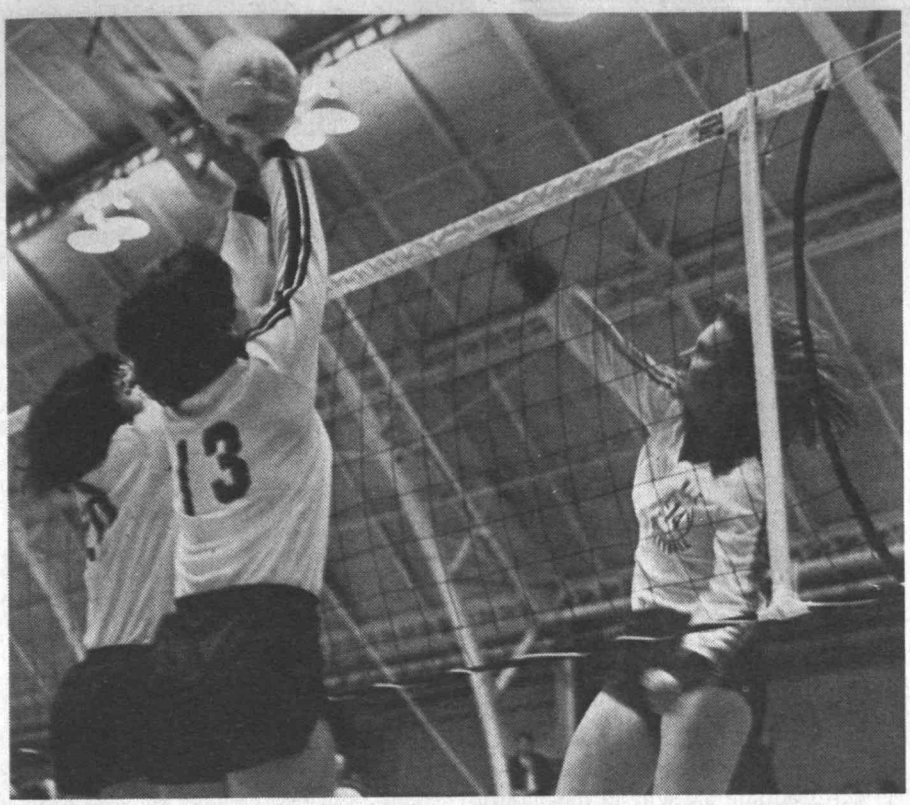
Forest City Enterprises, Inc., of Cleveland, under which the company will plan, design, construct, market, and operate a development of housing, businesses, and industries.

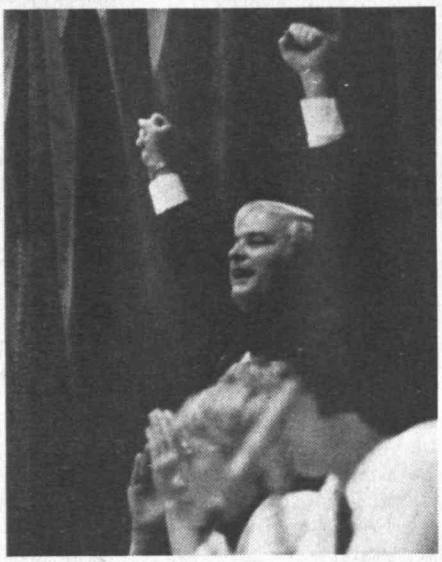
Forest City was selected early last year in a competitive process, and the papers signed in the fall confirm that selection. But they don't specify the exact mix of facilities to be built, or—of course—the tenants. Forest City must now develop final plans and market the facilities they contain, and no construction is expected for at least another two years.

Haystack Director

Joseph E. Salah, Ph.D.'72, who's been a member of the Lincolon Laboratory research staff for more than 15 years, is now director of the Haystack Observatory; he succeeds John V. Evans, who left to become vice-president for research at Comsat Corp.

Salah was a student of Evans for his Ph.D., and he has recently been leader of a Lincoln group studying atmospheric and radar reflection phenomena associated with atmospheric re-entry





OMAR S. VALERIO, '85, FROM THE TECH

President Paul E. Gray, '54, was among the cheering throng (below) when the women's volleyball team captured the New England championship. But at the nationals in California (left) it was another story: a 0-2 record left M.I.T. in the fourth-place spot in the U.S.

and with countermeasure technology. Haystack, whose principal instrument is a 120-foot parabolic antenna operating as a radio observatory, is used for research by students and faculty from universities throughout New England and by Lincoln Laboratory for satellite observations.

$2.2 Million Curriculum Fund From Bernard Gordon

Ever since he successfully launched Analogic Corp. shortly after graduating from M.I.T., Bernard M. Gordon, '48, has been a champion of training in innovation and the practical side of engineering at his alma mater. Now he's supported that posture with a $2.2 million gift for a Bernard Marshall Gordon Undergraduate Engineering Curriculum Development Fund.

The gift will be used in two ways, says Gerald L. Wilson, '61, dean of the School of Engineering:

☐ $1 million will endow a fund for long-term support of undergraduate curriculum development in the School of Engineering.

☐ $1.2 million will meet immediate curriculum development needs—including new textbooks, experimental subjects, and teaching materials to keep courses abreast of the rapid pace of change in technology and the business environment.

Real Estate Goes Academic

Continued from page A16

But that stereotype of the profiteering developer who is heedless of the poor and the environment is now largely out of date, says Samuel R. Pierce, Jr., secretary of the U.S. Department of Housing and Urban Development, who spoke at an opening convocation for the new center last fall. Today there are countless examples of "responsible partnerships" in the development field.

At the same time the field is becoming vastly more complex—larger projects, more complex design and engineering, many financial partners, new zoning and other environmental constraints. "Professional thinking and analysis are imperatives if we are to develop and construct in ways that will enrich our quality of life," Pierce told the fall convocation. The new center "can greatly enhance our ability to meet and master the housing and development problems of today and tomorrow."

Learning by Accident

Spaulding's sense of the need for formal education in real estate development led him to contact Glenn P. Strehle, '58, treasurer of M.I.T., early in 1983, and Strehle led him in turn to John de Monchaux, dean of the School of Architecture and Planning, and to Professors Gary Hack, '65, and Lawrence Bacow, '72, in the Department of Urban Studies and Planning, where the center soon found its home. A survey of 45 developers quickly confirmed Spaulding's judgment that the need was unfilled and very large. Most of today's developers have acquired what skills they have "through the accidents of experience," Spaulding says. And architects and engineers doing development work know almost nothing about management, finance, and marketing.

The center's master's program will draw faculty from throughout M.I.T.—planning, management, and engineering. Its students will study in each of the major disciplines that shape the development process—design, planning, construction, management, finance, and marketing. And because a number of these subjects will make extensive use of microcomputers, the master's program will open with a one-week intensive course on the use of computers in real estate investment and marketing.

There will also be research in the center in all these areas. Topics now being developed, according to Professor Bacow, who is the center's director of education and research: the problem of public/private partnerships, management of the public approval process, and how to model demands for space and tenants' choice in design and construction.

Obituaries

H. Steinbrenner

Whitworth Ferguson, 1900-1983

Whitworth Ferguson, '22, chairman of the Ferguson Electric Construction Co., Buffalo, who was a leader of his class and of M.I.T. activities in western New York, died on November 2, 1983, after a long illness. He was 83.

Mr. Ferguson had been a member of the Educational Council since 1940 and secretary of his class since 1957; he was a founding life member of the M.I.T. Sustaining Fellows. He received the Alumni Association's Lobdell Award in 1981.

Henry G. Steinbrenner, 1904-1983

Henry G. Steinbrenner, '27, a leader in the transportation industry who served as president of Kinsman Transit Co. (Great Lakes shipping) from 1947 to 1963, died at his home in Westlake, Ohio, on November 7, 1983. He was 79.

Steinbrenner majored in naval architecture and marine engineering at M.I.T. and as an undergraduate was noted for his interest and success in athletics. He twice won All-American recognition in track and was the only M.I.T. entrant ever to win an outdoor national track championship. His name is now associated with a stadium for track and field on the M.I.T. west campus.

Michael J. Miller, 1961-1983

Michael J. Miller, a third-year graduate student in architecture, disappeared while hiking with two friends in the White Mountains on October 23 and has been presumed lost. He was 22.

Weather conditions in the Mount Lafayette area were wintery, and a week-long search failed to uncover any clues to Miller's disappearance. Miller, general manager of M.I.T.'s radio station WMBR, was an important figure in Boston "rock" music circles.

Nikki J. Veltfort 1955-1983

Nikki J. Veltfort, '80, a second-year graduate student in mechanical engineering, was found dead in her car near the M.I.T. campus on November 30. She was 28, and her death was ruled a suicide.

Ms. Veltfort was working on engine control research in the Sloan Automotive Laboratory. She was an accomplished glider pilot, an active member of the M.I.T. Soaring Association, and she was also a member of the M.I.T. Sports Car Club.

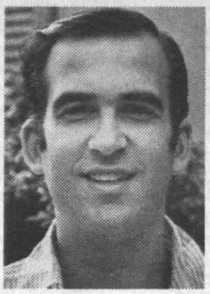
Deceased

Norman E. Borden, '02; January 5, 1972; Berlin Pond, RFD 4, Montpelier, Vt.
Harold E. Akerly, '10; August 21, 1983; 210 Palm Trail, c/o Sanderson, Delray Beach, Fla.
Edward A. Downey, '13; February 14, 1983; 7118 Pershing, St. Louis, Mo.
George B. Sampson, '13; April 1, 1982; 607 Beech St., Holyoke, Mass.
David Stern, '13; May 19, 1983; 99 Sandy Hill Rd., Newton Highlands, Mass.
Philip A. Russell, '14; September 24, 1983; 44 Fenimore Rd., Scarsdale, N.Y.
Walter J. Wolfe, '16; August 18, 1983; 1904 Virginia Dr., Bradenton, Fla.
Frank L. Butterworth, '17; November 29, 1983; 621 Spencer Ave., Marion, Ind.
Harry Fine, '17; October 4, 1983; 86 Island Circle, Sarasota, Fla.
Albert F. Hegenberger, '17; August 31, 1983; Route 1 Box 169, Maitland, Fla.
Herbert L. McNary, '18; May 8, 1983; 151 Hallet St. No. 427, Dorchester, Mass.
Howard R. Wade, '18; December 18, 1982; 408 Highland Ave., c/o Jeannette L. Cardia, Somerville, Mass.
Charles E. Packard, '20; September 2, 1980; 501 So. Center, Ashland, Va.
Dorothea D. Rathbone, '20; February 13, 1982; c/o Mrs. C. Dew, Indian Hill Rd., West Newbury, Mass.
William Robert Barker, '21; December 25, 1982; Fairfield Nursing Home, 1454 Loop Rd., Crownsville, Md.
Charles L. Manneback, '21; December 15, 1975; 27 Rue De La Tourelle, 1040 Brussels, Belgium.
David M. Broudy, '22; November 16, 1982; 865 West End Ave., New York, N.Y.
Haskell B. Curry, '22; September 1, 1982; 228 East Prospect Ave., State College, Penn.
George B. Danenhour, '22; May 28, 1982; 231 New Providence Rd., Mountainside, Westfield, N.J.
Whitworth Ferguson, '22; November 2, 1983; 925 Delaware Ave., Buffalo, N.Y.
James M. Shoemaker, '22; June 1983; 4000 Cathedral Ave. NW, Washington, D.C.
Albert V. Tiley, '22; April 26, 1983; Dennison Rd., Essex, Conn.
David A. Weill, '22; November 5, 1981.
Irwin W. Alcorn, '23; November 3, 1983; 2112 E. 25th St., Tulsa, Okla.
Theodore M. Bumiller, '23; October 18, 1982; 3414 Morrison Pl., Cincinnati, Ohio.
Richard Hittinger, Jr., '23; February 11, 1982; 431 School St., Belmont, Mass.
George N. Norris, '23; October 7, 1983; Carlton House Apt. 2-1, 2320 Commonwealth Ave., Auburndale, Mass.
James M. Robbins, '23; November 23, 1983; Rd. No. 1 Box 17-H, Lenape Ln., Salisbury Mills, N.Y.
Richard C. Robin, '23; September 8, 1983; 47 Bougainvillea Ln., Fort Myers Beach, Fla.
Elton W. Willis, '23; July 24, 1983; 238 West Tampa Ave. Apt. 319, Venice, Fla.
Vernon M. Ayles, '24; March 1982; 88 Acorn St., PO Box 35, Marshfield, Mass.
Louis B. Freeman, '24; February 10, 1983; 49 Hillside Ave., Madison, N.J.
Franklin J. Sawyer, '24; 1979; Sawyer Industries, Inc., 4001 New Ct. Ave., Syracuse, N.Y.
John W. Gillies, Jr., '25; September 2, 1983; PO Box 203, Locust Valley, N.Y.
Edward H. Long, '25; July 9, 1982; Hilltop Village Inc., Hilltop Circle, Kerriville, Tex.
George L. Washington, '25; June 4, 1983; 1301 Pennsylvania Ave. NW, Suite 1150 c/o Dillon, Washington, D.C.
Walter N. Westland, '25; May 25, 1982; 3 Trinity Ct., c/o Nye, Wellesley, Mass.
John E. Woodward, '25; July 6, 1982; 2121 Gulf Shore Blvd. N, Naples, Fla.
Douglas P. Jeppe, '26; August 13, 1982; 6027 Perrier St., New Orleans, La.
Marcellus B. McDavitt, '26; November 17, 1981; Santa Anita Club De Golf, Apartado Postal 31-9, Guadalajara 5 Jalisco, Mexico.
Donald S. Osborne, '26; November 5, 1983; 4933 SW 42nd Ave., Portland, Ore.
John G. Schultz, '26; December 8, 1982.
Julius L. Speert, '26; August 5, 1983; 3737 Clarks Ln., Baltimore, Md.
Ralph E. Derby, '27; October 16, 1983; 59 Highland St., Salem, Mass.
Frank C. Hutchison, '27; September 29, 1983; 25521 Lincoln SP 89, Hemet, Calif.
Frank L. Meyer, '27; 19769; Meyer Furnace Co., 1300 S. Washington St., PO Box 989, Peoria, Ill.
Henry G. Steinbrenner, '27; November 7, 1983; 1400 Prince Charles Ave., Westlake, Ohio.
Parker J. Ward, '27; January 13, 1976; 3430 Valley View Dr., St. Joseph, Mich.
Winston L. Campbell, '28; 1976; PO Box 1708, Washington, D.C.
Edwin F. Celette, '28; September 27, 1983; 1340 Pine-Needle Rd., Venice, Fla.
Donald S. Cryder, '28; March 31, 1983; 5908 Garden Ln., Bradenton, Fla.
Grant Y. Flynn, '28; October 26, 1983; 2404 Riverbluff Pkwy., Sarasota, Fla.
George D. Ross, '28; March 27, 1983; 109 Oxford Rd., Newton Center, Mass.
William W. Carter, '29; June 15, 1983; 2328 E. Hill Ave., Cincinnati, Ohio.
Denis A. Dearle, '29; June 28, 1983; PO Box 1914, New Britain, Conn.
Owen R. Garfield, '29; June 30, 1982; 204B Huntington Dr., Lakewood, N.J.

Alton G. Knight, '29; 1982; 490 Litchfield St., Torrington, Conn.
Leslie E. Simon, '29; October 28, 1983; 1761 Pine Tree Rd., Winter Park, Fla.
George W. Tidd, '29; January 5, 1981; 181 Elderfields Rd., Manhasset, N.Y.
James D. Egleson, '30; November 8, 1980; c/o Nicholas Egleson, 755 West End Ave., New York, N.Y.
W. Beverly F. Ottaway, '30; October 31, 1983; 6 Duxbury Rd., Wellesley, Mass.
Felix B. Padilla, '30; October 31, 1982; 123 A Mabini St., Mandaluyong Rizal, Philippines.
Mario V. Caputo, '31; June 5, 1983; 22 Bacon Rd., Belmont, Mass.
Louis P. Evans, '31; August 27, 1983; 545 King St., Woodbury, N.J.
Louis L. Colin, '32; September 1983; 4 Ascot Rd., Avondale West, Harare, Zimbabwe.
Robert W. Lawson, '32; April 27, 1981.
Stephen Lichtblau, '32; December 24, 1980; 1631 Pratt Dr., New Orleans, La.
Webster E. Morse, '32; February 23, 1975; 16 Euclid Ave., Quincy, Mass.
Gilbert A. Gerridge, '33; October 24, 1983; PO Box 82, Easton, Mass.
Marc Gilbert, '33; May 30, 1981; 143 Des Emeraudes, Boischatel, PQ Canada.
Outerbridge Horsey, '33; August 18, 1983; 3305 Dent Pl., Washington, D.C.
Stewart J. Hungerford, '33; December 1979; c/o Bethtex Industries Ltd., 1148 Goodwin St. Apt. 405, Victoria, BC Canada.
Alexander Sledge, '33; August 3, 1983; 33 Cliff Ct., Highland Park, N.J.
George Wrigley, Jr., '33; October 25, 1983; 216 Sweetbriar Rd., Greenville, S.C.
Frederick W. Baumann, '34; July 14, 1978; 315 Wren St., Scotia, N.Y.
Richard J. Fenlon, '34; May 25, 1975; 6 Sheldon St., Haverhill, Mass.
Richard F. Miller, '34; February 2, 1983; 817 Brock St., Winter Park, Fla.
John R. Charles, '35; September 30, 1982; PO Box 885, Islamorada, Fla.
William P. Douglass, '35; July 3, 1983; 9677 Paseo De Oro, Cypress, Calif.
Albert Willard Jackson, '35; May 15, 1982; 8 Doud Dr., Los Altos, Calif.
Jeremiah P. O'Connor, '35; June 4, 1976; 680 Blvd., Revere, Mass.
Cason Rucker, '35; June 20, 1983; 303 Reynosa Ave., St. Simons Island, Ga.
Albert F. Sanderson, Jr., '35; October 5, 1983; Playa Azul III, Apt. 2202, Luquillo, P.R.
John J. Seaman, '35; August 5, 1982; 4849 Terrace Dr., Niagara Falls, N.Y.
Alan E. Brigham, '36; September 10, 1983; 30 Mandalay Rd., Springfield, Mass.
Philip J. Gordon, '36; September 14, 1983; Maple Ave., Lawrenceville, N.J.
Frederick A. MacDonald, '36; November 11, 1983; 121 Gilson Rd., Scituate, Mass.
Julien Thomas C. Waram, '36; March 1982; 1132 Runningsprings Rd. No. 3, Walnut Creek, Calif.
Joseph E. Flynn, '37; September 24, 1983; 1421 Highland Pl., Winter Park, Fla.
Goodwin R.F. Gay, '37; August 31, 1983; 90 Maynard St., Northborough, Mass.
Percy F. Hurt, '39; May 30, 1981; PO Box 852, Windermere, Fla.
Paul Baral, '40; November 5, 1983; 3140 Butler Ave., Los Angeles, Calif.
John J. Dineen, '40; May 15, 1981; RFD 1 Mitchell Rd., Durham, N.H.
John S.R. James, '40; April 15, 1969, PO Box 35, Stockbridge, Mass.
Edmund Williams, Jr., '40; 1975; Pennswood No. I-32, 20 Haws Ln., Philadelphia, Penn.
Donald E. Ackerman, '41; April 20, 1983; 105 Maumee Dr., Monroe, Ohio.
Pierre F. Hartshorne, '41; May 13, 1982; 812 Jornada Dr., Las Cruces, N.M.
Andrew H. Prucknicki, '41; August 27, 1982; 22 Huckleberry Rd., Lynnfield, Mass.
Robert B. McBride, '42; July 22, 1982; PO Box 3603, Sarasota, Fla.
William N. Richardson, '42; June 22, 1976; Route 1, Reform Plantation, Natchez, La.
Herbert C. Sanderson, '43; January 1983; 1500 Lake Shore, Orlando, Fla.
Howard H. Scott, '43; October 12, 1983; PO Box 6, Gilbertville, Mass.
Oscar K. Burns, '45; June 23, 1982; PO Box 174, Chadds Ford, Penn.
Frederick C. Muller, '46; March 24, 1983; 5603 Hawthorne St., Cheverly, Md.
William Ward Powell, Jr., '46; December 7, 1981; 1615 Burnley Rd., Charlotte, N.C.
Anthony S. Urano, '46; June 8, 1983; 2101 Cantle Ln. SW, Roanoke, Va.
Milton White, '46; September 26, 1982; c/o Wible, 3701 S. George Mason Dr. No. 1305, Falls Church, Va.
Salvatore Fucci, '47; April 11, 1983; 50 Shelter Hill Rd., Plainview, N.Y.
James E. Retzer, '47; January 13, 1979; PO Box 208, Hardin, Ill.
Joseph W. Vorndran, '47; October 26, 1983; 3125 Mountain View Ave., Los Angeles, Calif.
Charles F. Maas, '48; July 6, 1976.
Elizabeth L. Marx, '48; June 1983; 2525 Via Carillo, Palos Verdes Estates, Calif.
Robert W. Roop, '48; June 2, 1983; 6 Wachusett Dr., Lexington, Mass.
Robert C. Van Renswaay, '48; January 1982; 241 Haverford Ave., Swarthmore, Penn.
Stanley J. Harshman, '49; November 12, 1983; 2956 E. 56th Pl., Tulsa, Okla.
William A. Bednar, '50; October 9, 1983; 47 E. Main St., Salineville, Ohio.
James W. Fry, '50; June 14, 1978; 13453 Beverly Blvd., Whittier, Calif.
John C. Nicholls, '51; May 9, 1981; PO Box 61A, Fiske Rd., Alburg, Vt.
Robert Astra, '52; November 4, 1983; 34 Michael Rd., Randolph, Mass.
Robert G. Hunt, '52; May 3, 1980; 17930 Karen Dr., Encino, Calif.
Robert S. Mayfield, '52; December 5, 1982; 3539 S. Zunis Pl., Tulsa, Okla.
Franklyn D. Owen, Jr., '52; March 1982; 5000 Wittering Dr., Columbia, S.C.
Renato N. Nicola, '53; June 13, 1978; 32 Foley St., Manchester, Conn.
William Stameris, '53; March 14, 1982; 51 Stewart Rd., Needham, Mass.
Barry S. Brissenden, '54; October 23, 1982; 60 Helene Ave., Dartmouth, NS Canada.
Charles Gilman, Jr., '54; January 1982; c/o Gilman Paper Co., 111 W. 50th St., New York, N.Y.
Alexander Penchuk, '57; February 22, 1983; 22 Curtis Rd., Natick, Mass.
Ralph J. Shemanski, '57; September 20, 1982; 133 No. Pompano Beach Blvd., Apt. 1410, Pompano Beach, Fla.
Thomas C. Thompson, '57; October 28, 1983; 240 Mt. Vernon St., West Newton, Mass.
Roger G. Sweet, '59; October 17, 1983; 12725 Walden Rd., Walden On The Lake, Montgomery, Tex.
George Steele Irons, '60; October 15, 1983; 47 Clifton Ave., Marblehead, Mass.
Frank J. Bednary, '61; August 1977.
Gerald T. Rogers, '61; January 16, 1975; 253 Beachview Dr., Fort Walton Beach, Fla.
Edward J. Goldblum, '63; July 11, 1983; 15 Netheravon Rd., London, England.
Carl M. Copenhaver, '65; March 7, 1983; 507 Forest Hills, Knoxville, Tenn.
Noel I. Morris, '65; October 22, 1983; 256 Mason Terr., Brookline, Mass.
John L. Nolte, '65; August 12, 1983; 5384 Havens Rd., Dryden, Mich.
Norman D. Wagoner, '67; November 1982; 1522 No. Buchanan St., Arlington, Va.
Karl W. Guenther, '69; March 11, 1976; 1939 Jackson, Ann Arbor, Mich.
Robert E. Weiskerger, '76; June 24, 1983; 156 Fox Hill Rd., Needham, Mass.
Heinz D. Besser, '80; November 11, 1981; Rua Antonio Parreiras 60/CO2, Ipanema, Rio De Janeiro, Brazil.
Nikki J. Veltfort, '80; November 30, 1983; 888 Massachusetts Ave. Apt. 215, Cambridge, Mass.

The Economic Theory of Baseball Stickers

Puzzle Corner/Allan Gottlieb



Allan J. Gottlieb, '67, is associate research professor at the Courant Institute of Mathematical Sciences of New York University; he studied mathematics at M.I.T. and Brandeis. Send problems, solutions, and comments to him at the Courant Institute, New York University, 251 Mercer St., New York, N.Y. 10012.

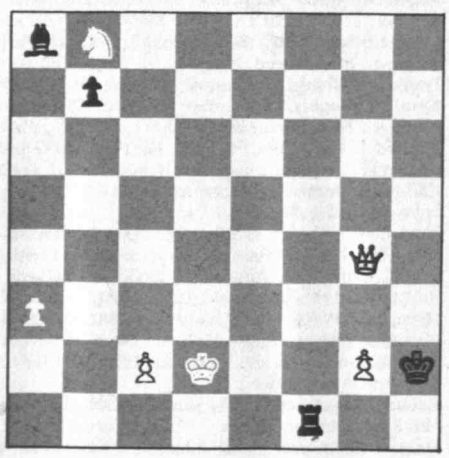
As you might know, essentially all problems that appear in "Puzzle Corner" are submitted by you, the readers of the column. So it's appropriate to report to you on the backlog of submitted problems awaiting publication. The largest backlog is for regular problems, where we have a one-and-a-half-year supply. For "speed" and bridge problems, the expected delay until publication is one year, and chess problems remain in short supply.

Let me repeat a comment about "speed" problems that I made in the October issue. These problems are often whimsical and should *not* be taken too seriously. If the proposer submits a solution with a problem, that solution appears at the end of the same column in which the problem is published. If the proposer does not submit a solution, normally one does not appear; only rarely are comments on speed problems published.

Finally, let me apologize to Steven Feldman for incorrectly listing his first name as Sidney.

Problems

F/M 1. We start with a chess problem from Daniel Seidman:



The problem: White to mate in two.

F/M 2. Here is an old chestnut from Matthew Chen: Three missionaries and three cannibals are on the left bank of a river and have to cross to the right bank using a boat that can hold two people. At least one person must be in the boat in order to move it from one side of the river to the other. On each bank, the missionaries must never be in a situation where they are outnumbered by the cannibals. How do all six people get across?

F/M 3. Lester Steffens wants to know the largest number of triangles that can be produced by passing a plane through a cube that is divided into 27 subcubes.

F/M 4. Robert Turner (son of $\int dt$) wants you to find a four-digit number whose square is an eight-digit number with middle four digits all 0; i.e. $(abcd)^2 = ef0000gh$

F/M 5. John Rudy wishes to better understand the economic theory of baseball cards (now converted to baseball stickers) and writes:
My nine-year-old son Brett collects baseball stickers. There are 260 in the set and they are purchased in groups of five for 20 cents. Topps also permits you to send away for groups of 10 (specific numbers) for $1 plus 20 cents postage (plus it costs 20 cents to mail). When is the optimal time to send away? What is the proper barter philosophy to have with friends?

Speed Department

SD 1. A bridge quickie from Doug Van Patter:

North:	*South:*
♠ A 10 9 7 6	♠ 5 4 3 2
♥ —	♥ A 9 8 7 6 5 2
♦ A Q 6 5 3	♦ 7
♣ 8 7 4	♣ 10 5

The bidding:

East	*South*	*West*	*North*
1 club	Pass	1 heart	2 hearts
3 clubs	3 spades	4 clubs	4 spades

(North's 2x bid shows five spades, five cards in a minor, and 10-15 points). By overly aggressive bidding, you (South)

become declarer in this four-spade contract. Since you can see that four clubs cannot make, you must try to make ten tricks. The defenders cash two club tricks, and you trump the third club. Can you find a reasonable line of play?

SD 2. Our final problem is from Phelps Meaker: An open-top cubical tank has an internal area in square decimeters equal to the weight of water it can hold in kilograms. How big is the tank?

Solutions

OCT 1. South is on lead and is to take all seven tricks against the best defense:

	♠ K ♥ 2 ♦ A 4 3 2 ♣ K	
♠ J 6 5 ♥ 3 ♦ 10 ♣ 8 3		♠ 9 8 2 ♥ — ♦ K Q ♣ Q J
	♠ A 10 7 ♥ K ♦ 5 ♣ A 10	

Dan Schwarzkopf and Amy Lowenstein first solved the unintended sub-problem (caused by the editor) of determining the trump suit and then proceeded to the main problem: If hearts are not trump, there is no solution; if spades are trump, West has a natural trump trick; if diamonds are trump, East has a natural trump trick; if the contract is no-trump, West can guard spades and East diamonds, eliminating the squeeze; and if clubs are trump, the XK cannot be used for ruffing purposes and the outcome is the same as in the no-trump situation.

With hearts as trump, South leads the ♠A at Trick 1, then continues with the ♠10. West has two alternatives:

1. If West fails to play the ♠J (or played it at Trick 1), Dummy discards a low diamond. South then trumps the remaining spade and overtakes, at Trick 4, the ♣K with the ♣A. South now plays the ♥K at Trick 5, squeezing East in the minor suits: if East releases a diamond, South leads a diamond to the ♦A and wins the last trick with the last diamond; if he releases a club, the last two tricks are won with the ♣10 and the ♦A.
2. If West plays the ♠J at Trick 2, Dummy ruffs, leads the ♣K, overtakes with the ♣A, and plays the ♥K at Trick 4, squeezing East in three suits: if East pitches a diamond, the ♦A and two low diamonds win the last three tricks; if East pitches a black-suit winner, South now has a winner in that suit and plays that card at Trick 5 (discarding a diamond from North). Again, if East discards the other black-suit winner, South plays the remaining black-suit card and wins the last trick with the ♦A, while a diamond discard results in two diamond winners in the North hand.

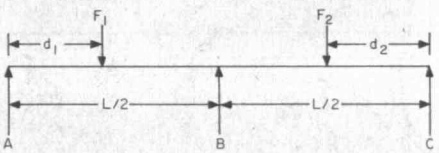
Also solved by Joel Feil, Robert Way, Matthew Fountain, Jerry Grossman, Winslow Hartford, D. Tumpler, Kenneth Bernstein, Richard Lesser, Lester Steffens, Richard Hess, and Doug Van Patter.

OCT 2. But of course, Fannie Dooley loves to baffle people. And Gefozzle them, too. You see, Fannie loves vanilla, but not chocolate. She loves Allan J. Gottlieb but not Robert Pease. She likes doors but not windows. She likes Mississippi, but not Alabama, California, or New York. . . . Also, she loves Arrowroot cookies . . . but doesn't care for tapioca. I told a couple of my friends, Lenna Mooree and William Llewellyn, and *they* figured it out. Fannie also loves the Massachusetts Institute of Technology and Harvard College, but not Princeton University . . . she likes cherry-wood furniture but not mahogany. Now do you see why? It's a fun game for people of 5th-grade mentality. . . . Of course, you have figured this out, but if you can't figure out why Fannie Dooley prefers all this hoop-la, to plain ordinary BLAH, ask a VOODOO doctor.

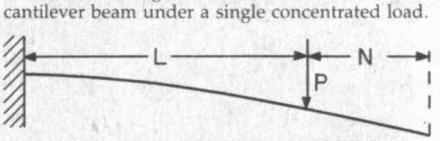
The key is that Fannie Dooley likes doubled letters. Warren Koontz believes that Fannie's name should be Doolee, noting that Dooley was the man who loved Laurie Foster but hated being hanged. Mr. Koontz also sent us a jingle from the PBS show "ZOOM" shown across the bottom of this page.

Also solved by Kenneth Bernstein, Karl Brendel, David Landress, Amy Lowenstein, Ronald Raines, Dan Sheingold, Ken Haruta, Harry Zaremba, Edgar Rose, Michael Yung, Dan Cooper, Steve Feldman, Matthew Fountain, Jerry Grossman, Emmet Duffy, Winslow Hartford, Richard Hess, John Woolston and D. Tumpler.

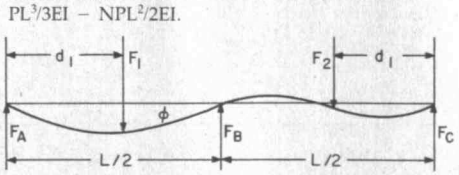
OCT 3. A massless beam of length L is supported by three stanchions A, B, and C at the ends and midpoint. The beam is loaded with point loads F_1 and F_2 at distances d_1 and d_2 from the ends. What is the downward force on each stanchion?



The following solution is from Matthew Fountain: This problem is best solved by the Myosotic method, named after the renowned Greek scholar Myosotic Palustris. We begin by quoting his formulas for the angular and linear deflections of a cantilever beam under a single concentrated load.



Angle: $PL^2/2EI$
Deflection: $PL^3/3EI$
These formulas apply at P. When the load P is a distance N from the free end, the angle of deflection is constant from P to the free end, making the deflection there
$PL^3/3EI - NPL^2/2EI$.



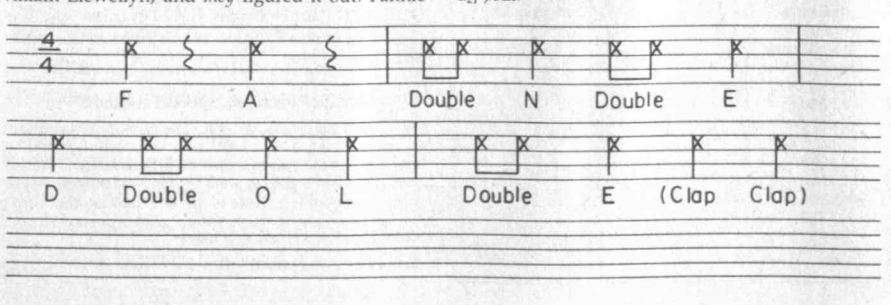
The beam in the problem is considered to be a pair of cantilevers fixed at B at angles ϕ and $-\phi$ with the line through A, B, and C. The forces F_1 and F_A cause a deflection of $(L/2)\phi$ at A to the left cantilever. The deflection at A due to F_A is
$-[F_A(L/2)^3]/3EI$
and the deflection due to F_1 is
$[F_1d_1(L/2)^2]/2EI + [F_1(L/2)^3]/3EI$.
The deflection at C of the right cantilever caused by F_C and F_2 is similar except that it is in the opposite direction. We can write
$-[F_A(L/2)^3]/3EI + (F_1d_1[(L/2) - d_1]^2)/2EI + (F_1[(L/2) - d_1]^3)/3EI = [F_C(L/2)^3]/3EI - (F_2d_2[(L/2) - d_2]^2)/2EI - (F_2[(L/2) - d_2]^3)/3EI$.
Taking moments about B, we can also write
$-F_A(L/2) - F_1[(L/2) - d_1] + F_C(L/2) - F_2[(L/2) - d_2] = 0$.
These two equations can be solved for F_A and F_C. F_B is obtained from the equation $F_A + F_B + F_C = F_1 + F_2$. With $R = (d_1/L)$ and $S = (d_2/L)$, the forces are:
$F_A = F_1[1 - (5/2)R + 2R^3] + F_2(2S^3 - \frac{1}{2}S)$
$F_C = F_2[1 - (5/2)S + 2S^3] + F_1(2R^3 - \frac{1}{2}R)$
$F_B = F_1(3BR - 4R^3) + F_2(3S - 4S^3)$
When $F_1 = F_2$ and $d_1 = d_2 = L/4$, $F_A = (5/16)F_1$ and $F_B = (11/8)F_1$. A beam hinged at B and similarly loaded would have $F_A = \frac{1}{2}F_1$ and $F_B = F_1$.

Also solved by Karl Brendel, David Landress, Ken Haruta, Harry Zaremba, Edgar Rose, John Prussing, Richard Hess, and the proposer, Benjamin Madero.

OCT 4. Show that for all $N \geq 3$
$$\sum_{k=0}^{N-1} \cos(4\pi k/N) = 0.$$

Donald Trumpler found this problem simple—once he made it complex: The sum is the real part of the complex sum
$$\sum_{k=0}^{N-1} e^{i4\pi k/N} = \sum_{k=0}^{N-1} (e^{i4\pi/N})^k.$$
This is a finite geometric series whose sum is
$[1 - (e^{i4\pi/N})^N]/(1 - e^{i4\pi/N})$
As long as $e^{i4\pi/N} \neq 1$. This is true if $N \geq 3$. But then the numerator $1 - (e^{i4\pi/N})^N = 1 - e^{i4\pi} = 0$. Thus both the given sum and the corresponding one with sin for cos = 0.

Also solved by Robert Way, Matthew Fountain, Jerry Grossman, Winslow Hartford, Harry Zar-



emba, Kenneth Bernstein, Harry Lieberman, Frank Carbin, Marion Berger, Mark Pinsky, and the proposer, Greg Schaffer.

OCT 5. In six root extraction problems, each x is to be replaced with a digit (duplicates permitted), the numbers are base 10, no leading zeros are allowed, and no zeros are allowed in the roots themselves.

The following solution is from Harry Zaremba:

```
      41                      511
√16 81                  ∛133 432 831
  16                      125
   81                       8 432
   81                       7 651
                              781 831
    4 11                      781 831
√16 89 21
  16                            5 111
   89                     ∛133 511 182 631
   81                       125
    8 21                      8 511
    8 21                      7 651
                                860 182
      41 11                   781 831
√16 90 03 21                     78 351 631
  16                             78 351 631
   90
   81                                    6111
    9 03                  ∜1394 5983 1095 1041
    8 21                    1296
      82 21                   98 5983
      82 21                   88 5841
                              10 0142 1095
                               9 1015 9041
                                  9126 2054 1041
                                  9126 2054 1041
```

The roots were obtained by using the following relations:

$$N^2 - a^2 = (2a + \Delta)\Delta$$
$$N^3 - a^3 = (3a^2 + 3a\Delta + \Delta^2)\Delta$$
$$N^4 - a^4 = (4a^3 + 6a^2\Delta + 4a\Delta^2 + \Delta^3)\Delta$$

in which the integer a is a digit multiplied by appropriate power of 10 for an initial estimate of the root, and integer X consists of a digit multiplied by a suitable power of 10 to represent successive estimates of the remainder of the root.

Also solved by Robert Way, Matthew Fountain, Norman Wickstrand, Avi Ornstein, Kenneth Bernstein, Richard Hess, and the proposer, John Woolson.

Better Late Than Never

1981 OCT 4. As noted by Emmet Duffy, the formula given in the October 1983 issue contains a typo: the third team should be positive. Mr. Duffy also enclosed a highly accurate approximate solution.

M/J 4. As noted by Joel Brenner, the argument given incorrectly assumes that no prime is divisible by 3 neglecting the obvious (and unique) counterexample of 3 itself. Indeed, 3,7,11 is a three-term arithmetic progression of primes with common difference 4. The analysis given in the October issue can now be applied to show that this sequence is of maximal length.

M/J 5. Smith D. Turner and La Ting found simpler solutions.

JUL 3. Michael Jung has responded.

A/S 3. Emmet Duffy and Michael Jung have responded.

OCT SD2. Paul Hoffman, Judy Bergman, and Jerry Horton found a solution requiring one less operation.

Proposers' Solutions to Speed Problems

SD 1. West must have the ♦K. The diamonds need to split 4-3 and the trumps 2-2. Lead your singleton diamond and finesse the ♦Q. Trump a diamond, then a heart, then another diamond. If all goes well, Dummy's diamonds are now good. Lead your last spade to the ♠A, play another trump. Lo and behold—the trumps drop! (My wife *made* this 14-point game with *exactly* this line!)

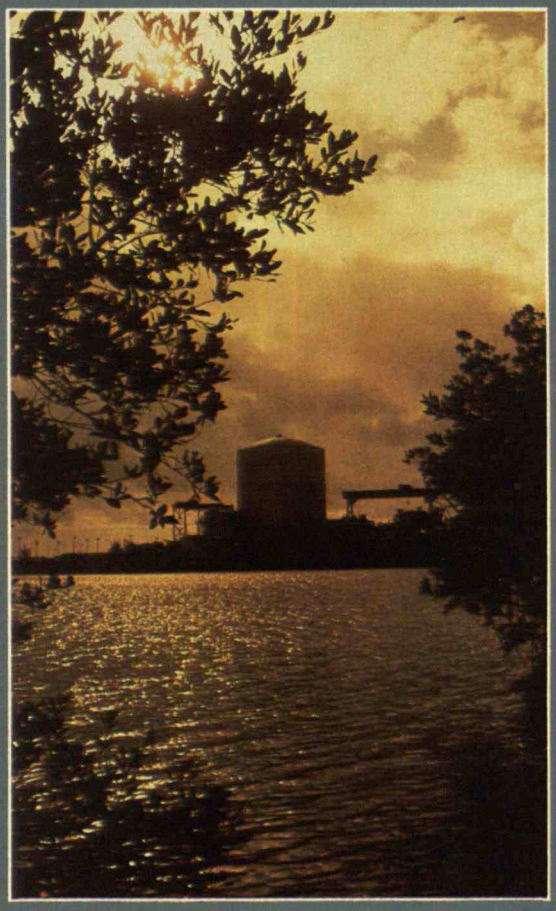
The Need for Nuclear Innovation

BY RICHARD K. LESTER

Almost ten years have passed since an American electric utility last placed an order for a nuclear plant that it did not later cancel, and no new orders are now in prospect. A drought of so many years would be more than enough to do away with many industries. Add to that situation the growing number of utilities facing financial crises brought on by the soaring costs of building nuclear plants, and many observers are ready to write off the nuclear option entirely.

But is the recent decline in the competitiveness of nuclear power really irreversible? If not, what is needed to turn the situation around? Could innovations in the design of reactors help to revive the faltering nuclear option? These questions are central to the future of the U.S. electric power industry.

The conventional wisdom in government and industry is to dismiss technological innovation as a solution to the nuclear crisis. According to this view, existing reactor technology is sound: the real problems are either external, and hence beyond the ability of the industry to control, or "institutional," requiring political or organizational reform rather than technological change. Let's consider these arguments in turn.

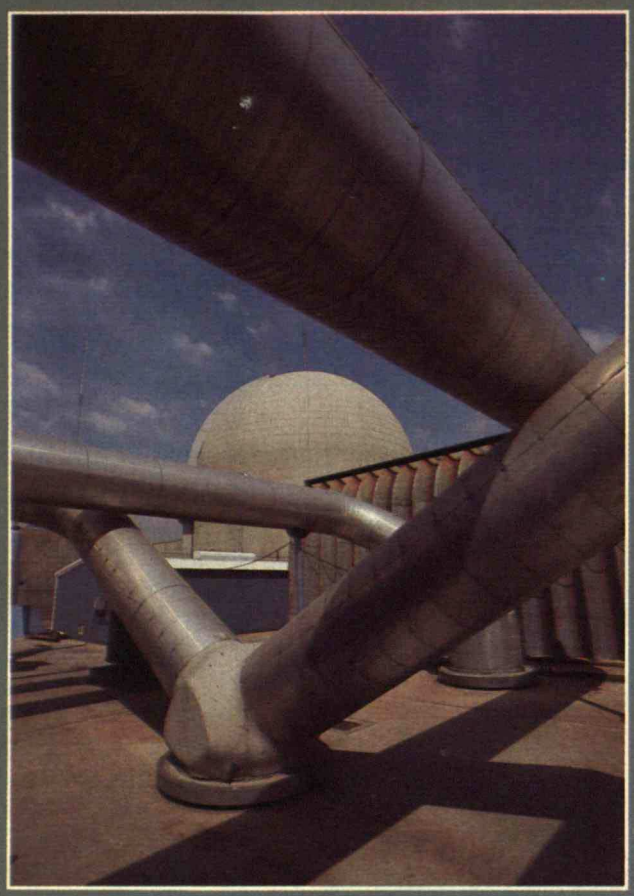


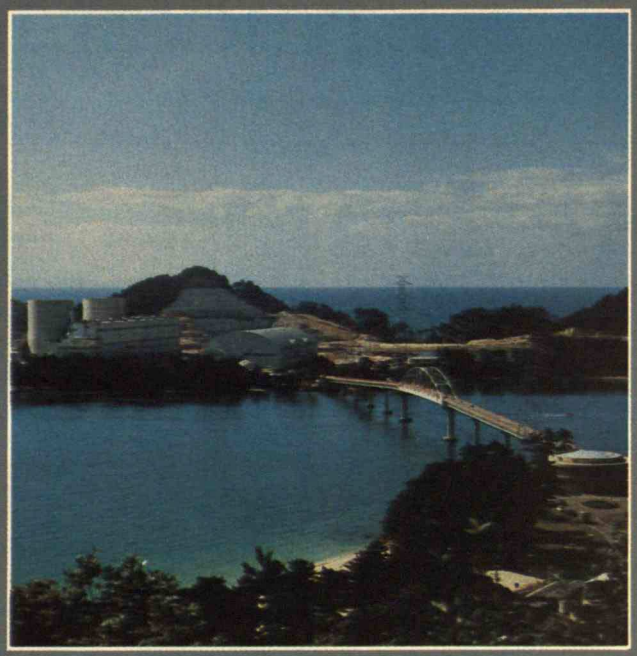
Utilities are afraid to order new nuclear plants because they fear unacceptable financial consequences. Two alternative technological strategies might overcome their reluctance.

Some of the most important reasons why utilities are not ordering new nuclear power plants do indeed lie beyond the scope of the industry's influence. This is clearly true of the sharp drop in the rate of growth of electricity demand in recent years, and also of the continuing spell of high U.S. interest rates, which have penalized nuclear relative to other, less capital-intensive options.

In regard to institutional problems, the nuclear industry has long been preoccupied with what it sees as excessive and unpredictable regulation, as well as antinuclear activism. But the industry now realizes that its own shortcomings in managing nuclear technology have contributed to its present difficulties. Indeed, many of the worst problems to befall the nuclear industry recently were self-inflicted. Examples include mistakes in executing designs, such as those that occurred at

PHOTOGRAPH: ATOMIC INDUSTRIAL FORUM





A large, modern nuclear plant contains ten million parts, according to one estimate, by contrast with the 300,000 in a jumbo jet. The complexity can overwhelm plant owners. New Jersey's Salem-1 reactor (left) twice failed to halt its fission reaction on command within three days. Japan's Mihama (below) also faced problems. But Florida's St. Lucie (preceding page) has functioned consistently without trouble.

the Diablo Canyon plant in California; mismanagement of construction projects, including the unhappy saga of Cincinnati Gas and Electric's problem-plagued Zimmer plant; and poor operating practices, such as those revealed by investigations into the recent failure of key safety equipment at the Salem plant in New Jersey.

Redesigning the Technology

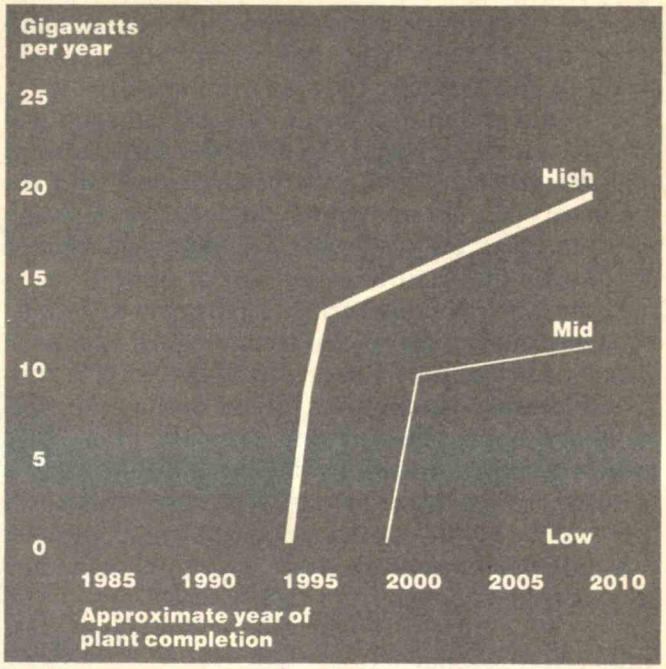
An underlying cause of many of the problems with nuclear power plants is the highly decentralized structure of the electric utility industry. Almost 60 U.S. utilities have committed themselves to generating nuclear power. Of these, about half will build no more than one reactor. Nuclear technology demands much of its users, and the fact that the user community is fragmented has inhibited the key process of technological learning. The result has been chronically uneven industrial performance. Some utilities have managed their nuclear projects effectively, but others have been unable to cope with the task. Since utility executives now recognize that the entire industry is damaged by the ineptitude of a few, they are seeking to upgrade general performance in constructing and operating nuclear plants. The success of such measures is critical to the future of the nuclear option. These initiatives include improving communications among utilities, standardizing products and procedures, and strengthening training programs. Some analysts doubt that these measures will be sufficient and advocate more radical reforms, such as consolidating nuclear plant construction and operation under the aegis of a few large regional organizations, or even a single national one.

But in the longer run, finding ways to do better with present technology ought not to be the only goal—and, at least where the more far-reaching reforms are concerned, may not be the most practical one. Management effectiveness obviously depends on the nature of the technology being managed. Hence, technological innovation could play an important role in making nuclear power more acceptable to utilities. For example, a fundamental cause of recent problems in constructing and operating nuclear plants is the extraordinary complexity of contemporary light-water reactors. Today's plants are vastly more complicated than those built a decade ago, and they tax the management expertise of even the most sophisticated utilities, let alone their weaker brethren.

A few plants, to be sure, have been completed

PHOTOGRAPHS: A.I.F.; ALLAN WEITZ, BLACK STAR

The future amount of new centralized capacity for generating electricity will depend mainly on the growth of demand. Even if that rate falls significantly below forecasts, the U.S. will require new plants with substantial capacity. The chart shows three possible levels of demand. All are based on the highest estimate for the longevity of coal plants, and on constant generation of electricity by existing oil and gas plants.



within budget and on schedule. A notable recent example is Florida Power and Light's St. Lucie unit 2. And some plants have consistently operated at high capacity. But despite efforts to raise the average performance of the industry toward these standards, utilities will probably continue to display a range of technical and managerial capabilities. Thus, advanced systems that place fewer burdens on builders and operators than contemporary designs could be the key to enhancing the attractiveness of the nuclear option. In fact, such designs have more appeal in the United States than in some other countries, where a more centralized industry has made it easier to achieve a more uniform performance. The central idea is to try to tailor the technology to the needs of the American electric power industry, rather than vice-versa. Obviously there is no technological "fix" for all nuclear power's problems, but that does not mean that design improvements have no role.

Ironically, efforts at innovation in nuclear power were aimed at quite a different target until very recently. The traditional view of reactor innovation, formulated when the industry was rapidly expanding, held that increases in the price of scarce natural uranium would pose the primary threat to the competitiveness of the nuclear option. Thus, the chief goal was to design and build nuclear reactors that consumed a minimum of uranium. However, the expected demand for nuclear electricity has declined sharply, and a good deal more uranium will probably be available at moderate cost than was once expected. Thus, reactor designers need no longer make conserving uranium their overriding objective—at least for the next few decades.

This was the main reason that Congress recently decided to end funding for the Clinch River Breeder Reactor. That action, though lamented by many industry leaders, will help focus attention on technical measures to combat the *real* threat to the competitiveness of nuclear power: the almost universal perception among utility executives and investors that ordering a new nuclear plant entails unacceptable financial risks. The most important technical innovations, therefore, are those that will lead to lower and more predictable capital costs for plants, shorter lead times, higher plant availability and reduced risks of major plant damage and long, costly power outages.

As it pursues these new goals, the nuclear industry must ask a fundamental question: should it make evolutionary improvements in the design of existing light-water reactors (LWRs) or shift to radically different designs? Proponents of an evolutionary strategy believe that the second option is unrealistic. They argue that it is wiser to draw on the great store of experience with LWRs than to pursue an unproven concept. They also argue that, despite its advantages on paper, any new concept would almost certainly encounter a long stream of unexpected problems similar to those that have plagued LWR technology. Moreover, they point out the great practical difficulty of changing the technological course of a large, inertia-ridden industry that has been strongly oriented toward LWRs for almost three decades.

Advocates of the alternative strategy contend that evolutionary improvement in LWR designs may not be enough to address the industry's fundamental problems. They argue that a more radical technological shift would not require a completely new start, as a good deal of LWR experience could probably be transferred. Furthermore, much experience with heavy-water-moderated and graphite-moderated, gas-cooled systems already exists both in the United States and overseas. These observers suggest further that the industry's reluctance to contemplate changing to new reactor designs may be much weaker a decade or so from now. (In fact, the longer the present moratorium on ordering nuclear plants,

Unless the utilities take the lead in specifying their technical needs for the next few decades, future innovations in reactors will be much less likely to succeed.

the easier a major departure from conventional light-water reactor technology will seem.) Some proponents of this strategy take an even stronger view. They contend that disaffection toward conventional LWR technology among the electric utility industry and the general public may be so strong, and the regulatory morass into which the industry has sunk so deep, that only a major technological change could prompt a return to the nuclear option.

In the Nuclear Engineering Department at M.I.T., we are exploring the role of technological change in making nuclear power more attractive to U.S. utilities. The two articles that follow outline the evolutionary approach and one example of a more radical technological shift. We make no attempt to choose between them. That is for the users—the utilities and the public—to decide. We do argue, though, that both paths deserve more attention than they have received so far.

Utility Seed Money

Commercializing advanced nuclear plant designs—whether improved LWRs or more radical innovations—will demand a significant up-front investment. Does the prospective market merit such expenditures?

Most of the nation's utilities now have a large surplus of generating capacity. However, productivity losses and retirement of old plants, as well as increasing demand for electricity, will require significant new capacity by the mid- to late-1990s. Small-scale decentralized sources such as solar-electric technologies, wind power, and cogeneration will help, but much of the new capacity will have to come from central-station baseload systems. In most regions of the country, the only candidates to meet this need in the next few decades are coal and nuclear power.

The amount of new central-station capacity needed will depend primarily on the growth in demand for electricity. The most recent projections by government and the electric-power industry suggest that demand will grow by between 2.5 and 3.2 percent per year from now to the end of the century. In the recent past, official forecasts almost invariably overestimated growth in demand. But even if the growth rate turns out to be significantly lower than this—under 2 percent per year, say—the nation will still require new plants, with a combined capacity of several thousand megawatts per year, to come on line starting in the late 1990s. (*See the chart on page 47.*) Thus, if nuclear energy can once again be made competitive with coal, a substantial market for new nuclear plants could emerge during the early 1990s.

Of course, that prospect is not enough to ensure the flow of money for innovative reactor designs. Existing reactor vendors, who have lost money on nuclear plants, are not likely to invest heavily in advanced nuclear systems without a fundamental change of attitude by the electric utilities. But these companies have been so scarred by their nuclear experiences that they are backing away from the nuclear option rather than encouraging a search for ways to make it more attractive. Also, utility executives worry that a major departure from conventional light-water reactor designs would raise new public and regulatory doubts about existing reactors. The utilities fear this could trigger another costly round of regulatory ratchetting. Finally, with the rapidly growing federal budget deficits, a vocal political opposition to nuclear power, and sharp cutbacks in the federal energy R&D budget, the prospects for a major government-funded initiative in nuclear power—even one that is a good deal less costly than the Clinch River project—are not particularly favorable.

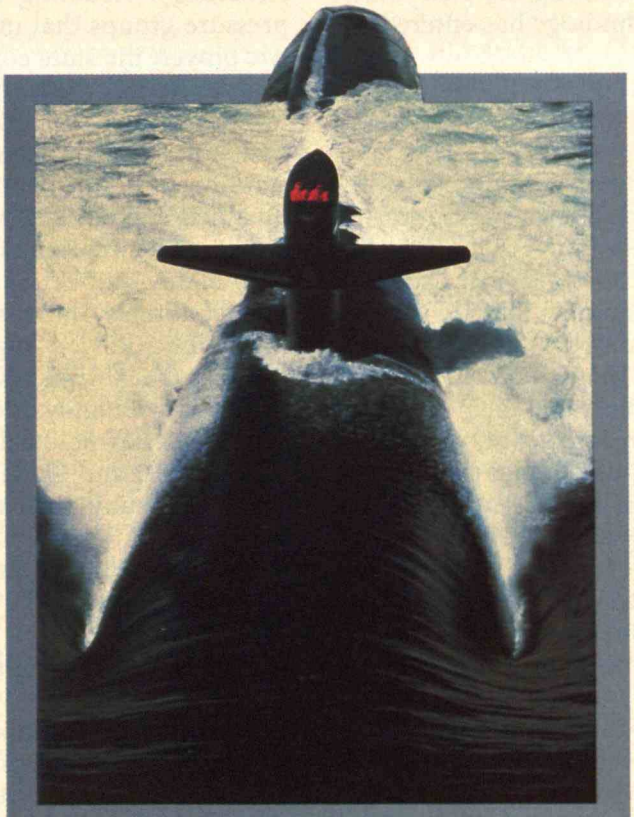
There is no easy way out of this impasse. The single most important step is for the electric utility industry to recognize that it must play a leading role in ensuring the timely availability of the technology that will enable it to sustain and improve the quality of its service. Without a clear financial commitment by the utilities, neither the traditional suppliers of nuclear reactors nor the federal government will be prepared to increase their efforts substantially.

There is also a technical reason for stressing the importance of leadership by utilities. The lack of experience and sophistication of the electric utilities in LWR technology has been a major cause of their difficulties in building and operating nuclear power plants. Unless the utilities take the lead in distilling their collective nuclear experience and specifying their technical needs for the next few decades, future innovations in reactors will be much less likely to succeed. Whether the utilities will rise to this challenge remains to be seen.

RICHARD K. LESTER is an associate professor of nuclear engineering at M.I.T. His current research deals with nuclear waste management, technological innovation, and international nuclear trade.

An Agenda for Improving Present-Day Reactors

BY MICHAEL W. GOLAY



The troubles of today's light-water reactors stem in part from their origins in the nuclear submarine program. To create a successful second generation of LWRs, utilities must change the way they design, operate, and manage their plants.

WHAT conditions are necessary in order to attract utilities to invest in improved versions of the light-water reactors that produce most of the nuclear power generated in the U.S. today?

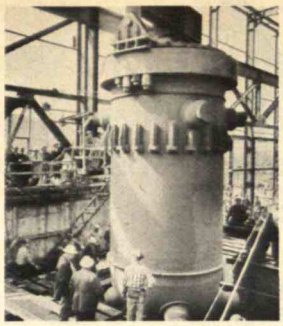
Because of their unhappy experiences with the technology so far, at Diablo Canyon, Three Mile Island, and a series of other reactors, many utilities are understandably wary about nuclear power in general and light-water reactors (LWRs) in particular. Even before considering any new LWR purchases, utilities will have to be convinced that the economic performance of any new generation of LWRs will substantially exceed that of the current crop, or that the economic risks of coal-fired plants are so great as to make LWR technology the lesser of two evils.

Certainly, current conditions would oppose the emergence of new LWRs evolved from the present generation. But our studies in the LWR Innovation Project at M.I.T.'s Department of Nuclear Engineering suggest that improved LWRs can satisfy the utilities' future needs—if the utilities are prepared to take a stronger role in setting performance goals for the new plants than they have taken for the old.

A fundamental source of the difficulties with the current generation of LWRs has been the diversified nature of the nuclear power industry. Manufacturers supply the reactor and its coolant system. Then, typically, architect-engineering firms design and build complete power plants around these systems, and utilities with varying levels of managerial and technical skill buy the plants and operate them. Federal, state and local authorities determine the safety and environmental regulations to which individual nuclear plants should conform at any given time. Because of the large number of possible combinations of manufacturer, engineering company, utility and regulatory requirements, it is rare to find two LWR plants that are exactly alike in the United States.

This system has developed naturally, as a result

PHOTOGRAPH: U.S. NAVY



of the utilities' experience over prior decades in introducing other innovative technology for generating electricity. The system, in which manufacturers would develop new technology and the utilities would purchase it, was established during a period in which business conditions were stable, technical change occurred slowly, and the risks associated with failures of technology were small. None of those conditions has existed during the past fifteen years, during which LWR technology has entered the marketplace.

Legacy of the Past

The performance of nuclear power stations has reflected that situation. The typical LWR station started up several years late, cost more than twice the original estimate to build, and now generates roughly 10 percent less electricity than anticipated.

Some portions of present-day LWR power stations have been more troublesome than others. In the past, engineers and designers concentrated their efforts on the central, fuel-containing reactor core, to the detriment of other components of the plants. This has had two unfortunate effects. First, system disruptions and component failures have frequently begun in the nonnuclear "balance-of-plant." The incident at Three Mile Island, for example, started with a loss of cold water pumping to one of the plant's steam generators—an event involving a part completely remote from the core.

In addition, current LWR plants are conceptual descendants of the U.S. Navy's nuclear submarine propulsion systems. The design goals for them were to minimize the system's volume and maximize the core life and the system's reliability. When this military technology was adapted for civilian use, the historic focus of design resources upon the fissioning reactor core remained, and it was largely taken for granted that the required safety systems and nonnuclear balance-of-plant would be as inexpensive and reliable as intended. Had this happened, the reliance upon the Navy's design goals would have been sufficient for economic success. With the advantage of perfect hindsight, it is clear that a more uniform distribution of design attention to all plant systems would have been wiser. It appears now that had this been done, by pursuing the goals of maximum simplification and reliablity and minimum construction time, the utilities could have produced plants that were far more economic.

Another cause for continuing concern among utilities comes from outside the industry. In recent years, state utility commissions have hindered the ability of utilities to build and operate nuclear plants satisfactorily. Reacting sympathetically to political pressure groups that insist upon low prices for electric power, the state commissions have caused many utilities to become chronically starved for cash. Few utilities in that situation are prepared to undertake new long-term projects, such as investing in power stations and hiring a sufficient number of well-qualified engineers to manage them.

The LWR situation is not entirely bleak, however. The highly publicized problems of some nuclear plants, notably Shoreham on Long Island, Washington Public Power Supply System in Washington state, and Seabrook, New Hampshire, are counterbalanced by highly successful but less well-known plants such as St. Lucie unit 2 in Florida, Dresden 2 in Illinois, and Connecticut Yankee. It is also notable that many nuclear projects in West Germany, Sweden, and Japan have typically out-performed those in the U.S., in terms of both capital costs and generating capacity.

Opportunities for Improvement

Clearly, substantial opportunities exist for improving the performance of LWR plants in the future. By learning from past experience, utilities can improve LWR technology if they change the way in which they design, operate, and manage their nuclear stations.

The key to a satisfactory second generation of nuclear plants is that the ultimate owners of the plants—the utilities—must formulate comprehensive, feasible design goals for them, and hire enough people with the technical and managerial skills needed to insist that the goals are met. A design goal requires an explicit statement on paper of all aspects of the plant's expected performance. This statement must be prepared in the most effective format, and must be supported by sufficient analysis to demonstrate that at least one method exists for meeting the

The age of U.S. commercial nuclear power dawned on Dec. 18, 1957, in Pittsburgh. Engineers in the packed control room at Duquesne Light Co.'s Shippingport plant released the first electricity at 12:39 a.m.

President Eisenhower, father of the "Atoms For Peace" plan, electronically kicked off groundbreaking for the plant in October 1954, and the reactor vessel was installed two years later.

goal. Engineers eventually translate the design goal into a design specification, which is the detailed documentation used by contractors as they strive to meet the utilities' requirements.

A well-prepared design goal would apply to LWR plants in general rather than to individual reactors. In accepting that consensus approach, the utilities would also be accepting a much greater degree of effective standardization on future LWRs than has been the case in the past.

Utilities might find that approach to power station design difficult to accept, because it would upset long-established patterns by which they have done business in the past. For one thing, it would require the utilities to become masters of the evolving technology rather than relatively passive consumers of products developed by others. That, in turn, would force the utilities to play a far greater role in the development of technology for the electrical industry than has previously been the case. While several leading utilities, such as Commonwealth Edison in Illinois, Duke Power in Carolina, and the Tennessee Valley Authority, have the technical ability to carry out a plan of this type, most do not. To develop the necessary capabilities, the latter will either have to expand their technical staffs and financial commitments considerably, or group together with more technically able utilities in consortia of the type that has not been common in the past. Whether utilities will be prepared to surrender their individual autonomy to promote the common good remains to be seen. If they are, though, they will benefit both themselves—by gaining more control of their own fates—and their customers—by supplying less expensive electricity reliably.

Strategy for a New Generation

Our study at M.I.T. suggests the following elements of an overall strategy for building and successfully running a new generation of light water reactors:

☐ The statement, by utilities, of a comprehensive, practical design goal, translation of the goal into a design specification, and tough enforcement of its requirements by the utilities' staffs.

☐ Complete design and planning of any project before any construction begins.

☐ Tight control of all aspects of the ongoing project by the utility's management.

☐ Emphasis on quality control throughout the construction.

☐ Active anticipation of all possible ways in which the plant might falter or fail in operation.

☐ Support of these goals by the utility, through a technically expert staff.

Our LWR Innovation Project is not the only study of its kind. The Japanese Ministry of International Trade and Industry (MITI) has coordinated a national effort involving Japanese utilities, reactor vendors, and Westinghouse and General Electric. In their project, the Japanese are formulating advanced LWR designs for use domestically and, of course, for export. In undertaking its project, M.I.T. is playing a role similar to that of MITI; the U.S. has no organizations equivalent to MITI.

Should the utilities spend their money to achieve the goals we suggest? Some members of the nuclear industry object that improving present LWRs is really unimportant; far better, they say, to spend the money on political action to rationalize governmental regulation of the industry and to persuade the public that nuclear power is not as hazardous as they think. We believe, however, that such efforts will almost surely fail. The United States' political system is inherently disorderly; no amount of lobbying will produce order in the regulation of nuclear power while the electorate is strongly divided on the issue of its safety.

These divisions will be erased only by a long record of successful, uneventful operation of nuclear plants. That might require decades. In fact, the process will not be complete until nuclear power plants become commonplace, and their operations become so regular that the public loses interest in them. That is exactly what happened with steam boiler technology and civilian air travel, both of which the public originally regarded as highly dangerous. We can only hope that the evolution of nuclear power will follow the same course.

MICHAEL W. GOLAY is associate professor of nuclear engineering at M.I.T. He has carried out research on reactor engineering, with special emphasis on safety and environmental factors. He now heads the LWR Innovation Project.

PHOTOGRAPHS: DUQUESNE LIGHT CO.

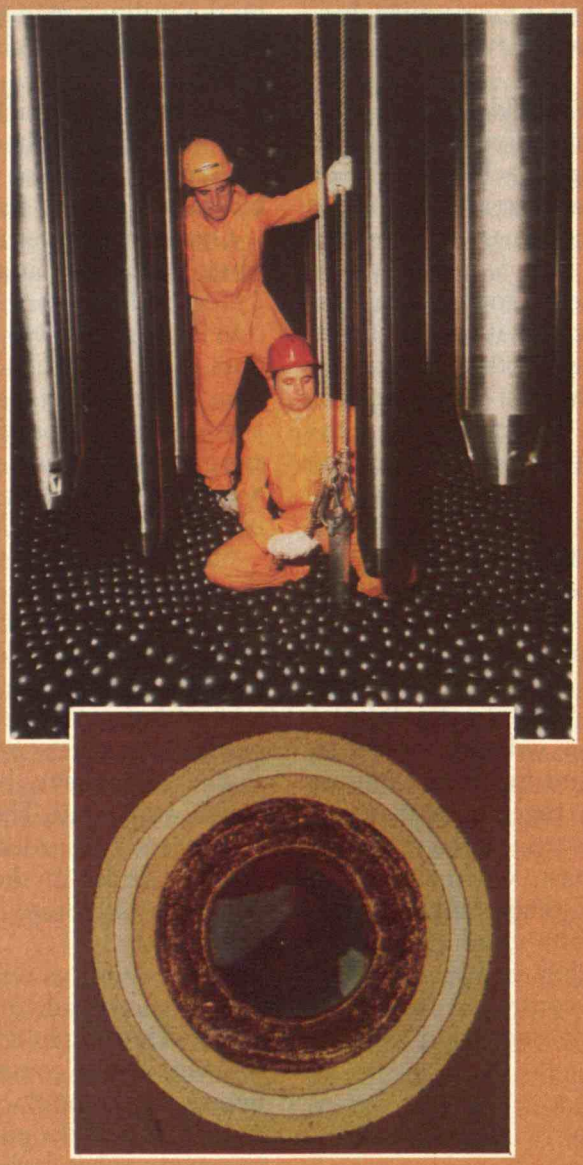
The Reactor of the Future?

BY LAWRENCE M. LIDSKY

CAN a new type of fission reactor solve the nuclear power problems of U.S. electric utilities? Is it realistic to believe that manufacturers will build, federal regulators will allow, and utilities will buy such radically different reactors? A growing coalition of manufacturers, utility planners, and engineers thinks the answer may very well be yes.

A group of professors and students in M.I.T.'s Department of Nuclear Engineering has come to the same conclusion: we believe the modular high-temperature gas-cooled reactor may be a "better mousetrap." We are now trying to determine whether this reactor—which would be much smaller and inherently safer than today's light-water reactors—can and should play an important role in generating the nation's electricity during the next decade and beyond.

This new reactor is also gaining the attention of Congress. Representative Don Fuqua of Florida, chairman of the House Committee on Science and Technology, recently called for expanded R&D efforts on "fail-safe" reactors in general, and on the modular high-temperature gas-cooled reactor (HTGR) in particular. In a November 14, 1983 letter to Donald Hodel, secretary of the U.S. Department of Energy (DOE), Fuqua said that inherently safe reactors "are necessary to reinvigorate the nuclear option, since it does not appear that public perception will improve greatly through incremental safety improvements which are chiefly obtained through increasing complexity." He went on to request that DOE include "roughly $75 million" in the 1985 budget to pursue the modular HTGR concept.

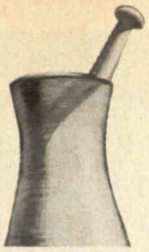


The modular high-temperature gas-cooled reactor (HTGR) that may rescue U.S. utilities has German roots. Here, workers load fuel spheres into the core of a 300-megawatt demonstration plant in Hamm-Uentrop. Each sphere contains some 35,000 fuel particles (bottom)—tiny kernels of uranium nestling in layers of graphite and silicon carbide.

The modular HTGR is actually a new variation on a relatively old theme. Utilities in Great Britain have used gas-cooled reactors for nearly 30 years, essentially the lifetime of commercial nuclear power. Indeed, nearly all British nuclear plants are cooled with carbon-dioxide gas. However, the reactor now attracting attention is cooled with helium. Being less corrosive and chemically less complex than carbon dioxide, helium allows the reactor to operate at higher temperatures than the British versions. And higher operating temperature means, of course, higher efficiency in producing power.

High-temperature gas-cooled reactors are not entirely unknown to utilities. The Philadelphia Electric Co. operated a 40-megawatt HTGR—the Peach Bottom developmental plant—from 1967 to 1974. The plant averaged a power-generating ef-

PHOTOS: GA TECHNOLOGIES; HRB



ficiency of 34.6 percent—that is, 34.6 percent of the energy released by the nuclear fuel was converted to electricity. Conventional light-water reactors usually average about 32 percent efficiency. The plant also proved extremely reliable, posting an "on-line" availability of 88 percent. Conventional reactors average about 65 percent availability.

A new type of fission reactor, smaller and inherently safer than conventional reactors, may reinvigorate U.S. electric utilities.

Next came the 330-megawatt Fort St. Vrain plant, located near Denver, which started producing power in 1974. This HTGR has generated more than 3.2 billion kilowatt-hours of electricity for the Public Service Company of Colorado, and has achieved a power-generating efficiency of nearly 40 percent. Built by GA Technologies (formerly General Atomic) in San Diego, the plant also shows that helium-cooled reactors are remarkably "clean." Utilities regularly monitor the exposure of workers to radioactivity during everyday job activities. Exposures to radioactivity at the Fort St. Vrain plant have amounted to less than 2 percent of exposures among workers in other nuclear power plants. This is particularly noteworthy because the plant was plagued with mechanical problems early on, which meant that workers were often making repairs on and around the reactor itself.

The Fort St. Vrain plant is the only HTGR now operating in the United States. Other utilities expressed interest in such reactors during the mid- to late-1970s, and even ordered a half-dozen reactors. However, these were canceled as utilities faced a declining demand for electricity and an unfavorable economic climate. Nevertheless, about 30 utilities, convinced that the HTGR has significant advantages, formed Gas-Cooled Reactor Associates (GCRA) to keep the technology alive. This group has coordinated the design of a large HTGR—an 855-megawatt plant dubbed the "Lead Project"—and is examining issues of licensing and financing. GCRA is also beginning to study the market potential of much smaller HTGRS.

High-temperature gas-cooled reactors are being pursued even more actively in Germany. Indeed, the German version of the HTGR—which uses a different fuel arrangement in the reactor core—is really the direct ancestor of the reactor that our M.I.T. group and others find promising for U.S. utilities. The Germans have been operating a relatively small 15-megawatt reactor (called the AVR) since 1967, and they are now completing an advanced 300-megawatt demonstration plant. This reactor (called THTR) recently "went critical"—meaning its nuclear fuel achieved a self-sustaining chain reaction—and the builders are beginning tests at low power.

The hallmark of the German reactors is that they are so-called "pebble-bed" reactors. The fuel sits inside graphite spheres about the size of baseballs—the "pebbles"—which are slowly circulated through the reaction chamber. In U.S. models, the fuel is incorporated in graphite blocks stacked up to form a fixed "prismatic core" within the reaction chamber. Although the two types of reactors have much in common, several operating characteristics make the pebble-bed design better-suited for small modular reactors.

To see how pebble-bed reactors work, let's start with the fuel. It is typically "low-enriched" uranium. (Because this fuel is only moderately more reactive than natural uranium, there is little likelihood that anyone would attempt to divert it for making nuclear weapons.) Tiny kernels of the uranium, about the size of specks of dust, are individually wrapped in layers of graphite and silicon carbide. This shell serves as a miniature pressure vessel, inside which the fission reactions take place, and traps the radioactive wastes produced. Some 35,000 encapsulated fuel particles are then uniformly embedded near the center of a graphite matrix, forming the baseball-size spheres "burned" in the reactor.

Several hundred thousand of these spheres comprise the reactor core, which fills the reaction chamber like so many beans in a jar. Thus, the core is essentially a huge mass of graphite. The heat produced as the uranium fissions inside the tiny fuel particles passes into the surrounding graphite. The coolant—pressurized helium gas—is forced through the core and is heated in the process. Extracted from the reactor, the hot helium is used to produce steam, which then drives turbines to generate electricity, just

Even if the worst possible accident should occur, the modular high-temperature gas-cooled reactor won't suffer serious damage or release radioactivity.

as in other power plants.

New fuel spheres are continually added through a port at the top of the reactor during operation. (This "on-line fueling" is one of the features that makes the pebble-bed design attractive for small reactors. Most prismatic-core reactors must be shut down when new blocks containing the fuel are added. Continual fueling also means that the core always contains only as much uranium as needed to keep the fission reaction going, which makes the reactor easier to control.) The spheres take several months to percolate through the core and are finally removed at the bottom. If the spheres still contain unspent fuel, they are recycled; spheres might pass through the reactor a dozen times. When the fuel is exhausted, the spheres are disposed of. The Germans do this by putting the spheres in iron cannisters, which are stored in underground caverns.

Built-In Safety

Why are HTGRs safer than today's light-water reactors? First, the graphite has what's called high heat capacity: it can absorb considerable amounts of energy without its temperature rising very much. As an analogy, consider two materials warmed over the same flame: the one with a higher heat capacity will warm up more slowly. Graphite also maintains its integrity at high temperatures, actually getting stronger as it gets hotter.

Second, the miniature pressure vessels containing the uranium are incredibly strong—their small size makes them proportionally much stronger than the equivalent structures in conventional reactors. The layer of silicon carbide also enables them to withstand high temperatures. In fact, researchers have determined that the fuel particles will remain intact at more than 2,000° C—more than 800° above the normal peak operating temperature. Moreover, essentially no radiation will "leak" from the particles at temperatures below 1,600° C.

Finally, HTGRs operate at a relatively low "power density"; that is, they produce less power per unit of reactor volume than conventional reactors. From one viewpoint this is a drawback, because, all else being equal, the more power produced the better. However, a low power density means there is less energy within the core to cause damage in the event of a mishap.

This combination of factors means that an HTGR's core will heat up very slowly during an accident. The core can also get much hotter before the fuel elements fail and the reactor suffers serious damage. Indeed, it would take several hours, perhaps even several days, for the core to reach dangerously high temperatures. The core of a light-water reactor, in contrast, can overheat quickly. For example, in the accident at Three Mile Island, the core overheated and partially melted in less than two minutes.

Thus, operators of an HTGR have much longer to correct any problems that might arise. And of special importance, they will have time to analyze the situation carefully and plan their actions accordingly. As one analyst has said, "Theoretically, operators could go down the street and have a cup of coffee while they ponder what to do about any trouble." This built-in protection has paid off at the Fort St. Vrain plant. The helium coolant stopped circulating for extended periods on several occasions without measurably increasing the temperature of the core or harming the reactor in any way.

All high-temperature gas-cooled reactors—large or small, pebble-bed or prismatic-core—have these safety advantages. However, the advantages are enhanced in *modular* versions because of the smaller reactor size. Imagine the worst possible situation: an equipment failure or an operator error somehow causes a total loss of coolant, and the control rods normally used to shut down the reactor fail to operate. The reactor is basically running on its own.

Both light-water reactors and HTGRs are designed so that the fuel automatically stops fissioning as soon as the temperature in the core rises much above normal. But even after the reactor shuts down, the accumulated fission products continue to release energy. In a conventional reactor, this "afterheat" from radioactive decay can produce temperatures high enough to damage the core within minutes. In a large HTGR, damage won't result for many hours because the core heats more slowly and can withstand higher temperatures. But in a modular HTGR, there is no danger at all. Its small size allows the afterheat to escape easily, even from the center of the core. The core's temperature can never get above the critical 1,600° level, which ensures that the fuel particles will release essentially no radiation. Thus, modular HTGRs have been called "walk-away" reactors; operators needn't take immediate emergency steps because the reactor protects itself. Studies show that reactors that produce about 80 to 100 mega-

Fort St. Vrain, the only HTGR in the United States, has proven more efficient and "cleaner" than conventional reactors. However, small modular versions look even better—inherently safer and more attractive economically.

watts of electricity—roughly one-tenth the size of the current generation of light-water reactors—will meet this requirement.

But Will They Sell?

Of course, utilities won't hurry to adopt modular HTGRs, even with their built-in safety advantages, unless the reactors are attractive economically. Current wisdom holds that large nuclear plants are cheaper to build than smaller plants, measured in terms of cost per kilowatt of generating capacity—the so-called "economy of scale" that characterizes many technologies. Thus, one might expect modular plants to be inherently more expensive than conventional nuclear plants. But to borrow Ira Gershwin's lyric, "It ain't necessarily so."

Conventional reactors must be built on-site. Workers painstakingly assemble thousands of components, while at the same time coping with the vagaries of the weather and unexpected construction problems. But reactors in the 80- to 100-megawatt range could be transported by truck—special trucks to be sure, but trucks nonetheless. This means that manufacturers could establish central factories for producing standardized reactor modules on an assembly-line basis. Thus, the "economy of serial production" might make up for the loss of economy of scale. This would even improve quality control: factory production would ensure that experienced workers build the reactors and encourage the use of the latest testing techniques.

Modular reactors can improve the overall performance of utility power stations. Consider a central power station composed of 4 to 12 HTGR modules. Because their simplicity and small size makes them extremely reliable, it is unlikely that more than one unit would be inoperative at any given time. And if other nonnuclear components were similarly modularized—for example, if there were several interconnected steam generators and turbines—the power station would be even more reliable. Such redundancy would ensure that the station could always generate electricity at nearly full capacity. By contrast, the performance of most U.S. nuclear generating plants has been disappointing: two-thirds of the plants have averaged an on-line availability of less than 60 percent. In today's economic environment, increasing plant reliability to just 80 percent would reduce the cost of the electricity produced by about 20 percent.

Utilities will be better able to tailor their generating capacity to consumer needs. Since demand for electricity is growing more slowly than in the past, utilities are reluctant to add expensive 1,000-megawatt reactors until absolutely necessary. However, they could more easily add several 80-megawatt HTGRs at a time, expanding generating capacity with-

PHOTO: PUBLIC SERVICE COMPANY OF COLORADO

Are we so traumatized by the resounding crash of the nation's nuclear power program that we lack the courage for a new beginning?

out outstripping demand. (An 80-megawatt reactor can supply enough electricity to serve 40,000 people.) And since modular reactors could be brought on-line faster, utilities wouldn't have to wait as long before they could start selling electricity and recouping some of their expenses. Many states prohibit utilities from passing on construction costs to consumers until the plant is completed, which now can take up to a decade.

Modular HTGRs might also help solve one of the most notorious problems plaguing light-water nuclear plants: the unpredictability of their construction cost. Some plants have been completed on time and within budget, but many others are still under construction long after their scheduled completion date and some will cost fully 10 times as much as planned. Utilities have paid between $800 and $4,000 per kilowatt of capacity for essentially identical reactors. However, factory-produced modular reactors will have a firmer price tag and completion date, eliminating much of the uncertainty for utility planners.

Shrinking the Safety Envelope

What's more, manufacturing the reactor won't interfere with installing the rest of the equipment at the power station. Today, workers need regular access to the reactor during construction—which may stretch over four to six years—and this largely determines the rate of progress for the overall plant. However, "balance-of-plant" construction actually represents about 75 percent of the cost of the completed power station, so delays are costly.

Using modular HTGRs may cut the cost of the balance-of-plant in an even more important, though less visible, way. In conventional nuclear plants, failure of a component not directly related to the reactor could theoretically trigger a sequence of events that might seriously damage the reactor core, and possibly release radioactivity. For example, the accident at Three Mile Island started with a loss of water to the plant's steam turbines. Thus, the Nuclear Regulatory Commission (NRC) says that if failure of an external component could possibly lead to a reactor accident—even if the reactor's safeguard systems should be able to terminate the sequence of events before the core is damaged—then that component must meet stringent standards. In the industry, such components are said to fall within the "safety envelope." Meeting the standards greatly increases the cost of building the balance-of-plant. Indeed, capital costs may be twice as much and labor costs five times as much as in oil- or coal-fired power plants.

However, failure of external components can't lead to reactor damage in modular HTGRs; the reactors protect themselves. Therefore, the safety envelope might be reduced to encompass only the building containing the reactor modules. The rest of the plant could then be built to the standards set for fossil fuel-fired power plants. This advantage might prove the most important issue in determining whether utilities will accept the new reactors. Of course, it's uncertain whether such changes in regulatory standards will be allowed. However, the NRC has begun to consider a new philosophy—emphasizing overall safety goals that nuclear plants must meet, rather than mandating specific construction details. This may enable utilities to capitalize on the inherent safety of modular HTGRs, freeing the reactors from standards mandated to solve the problems of other reactors.

Finally, modular HTGRs can minimize a utility's "down-side" risk. Five years after the accident at Three Mile Island, that reactor remains out of operation. The cost of cleanup and repairs has already reached into the billions of dollars. However, the "walk-away" capability of modular HTGRs means that no malfunction could seriously damage the plant, which ensures protection of the owner's investment. Indeed, the goal is to develop reactors with a "walk-back" capability. If an operating mishap should occur, the plant could be restarted quickly—and return to producing revenue—without expensive cleanup or repairs.

Thus, modular HTGRs can, in principle, help remedy the current woes of U.S. utilities. The reactors also hold considerable promise for use in developing nations, which would appreciate their safety and reliability as well as their suitability for increasing electrical generation incrementally to match demand.

Our group at M.I.T. is now working with several other groups to determine whether the modular HTGR looks as good on close inspection as it does given our present knowledge. There is some evidence that this will be the case. The next, and most important, question will be whether the public, Congress, regulatory agencies, utilities, and the engineering community are so traumatized by the resounding crash of the nation's first-generation nuclear program that we lack the courage for a new beginning.

LAWRENCE M. LIDSKY is a professor of nuclear engineering at M.I.T. He received a Ph.D. in nuclear engineering from M.I.T. in 1962.

The new '84 Ford Tempo. Technology never felt so comfortable.

The inside story.

Tempo's interior is a computer-refined compartment for five. Computer-designed placement of seats, door, roof and window areas afford maximum space efficiency.

Even Tempo's front-wheel-drive configuration was designed to provide more interior room. Since there is no drive shaft, there is no large hump to rob valuable floor space. In fact, Tempo actually has more rear room than a Mercedes 300D.*

For driver's convenience, controls are all placed within easy reach. For added ease, wipers and washer, directionals, high-beams and flash-to-pass are located on the steering column itself.

Technology that works for you.

Outside, a unique aerodynamic shape channels the wind over and around Tempo to help increase fuel efficiency. It also directs the airflow, reducing overall lift for improved stability and directional control.

Its front-wheel drive delivers all-weather traction, while its four-wheel independent suspension provides a smooth ride.

Plus, Tempo has the world's most advanced automotive computer, the EEC-IV. It processes up to 250,000 commands per second. Coupled with Tempo's 2300 HSC (High Swirl Combustion) engine, you get quick power response from a standing start and at cruising speed.

Best-built American cars.

When we say "Quality is Job 1," we are talking about more than a commitment. We are talking about results. A recent survey concluded Ford makes the best-built American cars. The survey measured owner-reported problems during the first three months of ownership of 1983 cars designed and built in the U.S. And that commitment continues in 1984.

*Based on EPA Interior Volume Index.

Have you driven a Ford... lately?

Ford

inventions and discoveries "conceived of" during employment to the firm. This could expose a venture to a lawsuit not only for any product developed during the principals' former employment, but for any product *thought of* during employment.

Admittedly, the courts have not been eager to enforce such provisions, and have used a variety of strategies to avoid their effect. For example, an Oklahoma court recently construed an invention-assignment provision to cover patents only, even though the agreement was not so limited. Other judges have been less subtle, simply deciding cases in the teeth of the facts. For example, one Illinois federal court judge ruled that the fact that an employee had roughed out some sketches for a machine to spread rock chips in road construction just days after he quit his job did not show that he had actually conceived of the design during employment. Another court ruled that a new-product proposal submitted by an employee was not covered by an assignment clause, because a similar product was already on the market.

Although such rulings might benefit an employee in a particular case, they do nothing to address the overall inhibiting effect of invention-assignment clauses on the thousands of employees who have signed them. Moreover, as beneficial as a judicial sleight-of-hand may seem for promoting innovation, it is a little unseemly for courts to be depriving companies of their contractual rights by distorting the terms of an agreement. Furthermore, judges can go only so far in stretching the terms of an agreement before they begin to feel uncomfortable.

A Legislative Solution

The social dilemmas posed by invention-assignment and confidentiality agreements are too important to be resolved on an arbitrary case-by-case basis. Moreover, the courts are not equipped to deal with the conflicting policy questions raised by such agreements. The potential effects of these agreements upon employee mobility, new-venture formation, and the rate of technological innovation clearly mandate systematic study and legislative resolution. A few states have adopted statutes barring employers from controlling the rights to inventions that do not relate to an employee's job responsibilities. A bill with similar provisions has also been introduced in the U.S. Congress. Unfortunately, such legislation is of little help to the vast majority of entrepreneurs who are only qualified to found enterprises that relate directly to their prior job experience.

As a society, we may conclude that certain types of contractual restraints on the use of employee-developed information are contrary to our national interest and should not be enforced by the courts. On the other hand, we may decide that all contractual restraints should be vigorously enforced in the interest of promoting R&D by established companies. In that case, the courts should stop trying to mitigate the effects of strict employer-employee agreements by creative interpretation. In either event, we should not stand back and allow our gifted employees to be put in a legal straitjacket without considering the economic and social consequences. We should anticipate a problem for once, instead of reacting once it becomes a crisis. □

ROBERT A. SPANNER is a trial lawyer in Palo Alto, Calif., specializing in trade-secret litigation. He is the author of Who Owns Innovation? The Rights and Obligations of Employers and Employees *(Dow-Jones-Irwin, forthcoming).*

Editorializing at Epcot

Alison Bass (*"Disney and the Corporate Con," October, page 18*) appears to reprove Exxon for stating in its exhibit that "scientists have developed methods to handle, stabilize, and store radioactive waste safely to protect the human environment." She prefers the more cautious statement in the Boston Museum of Science's exhibit, "Numerous technologies for high-level radioactive waste disposal are under investigation." My question: If Exxon believes (as I do) that methods have indeed been developed, why not say so? Better that than leave the general public under the impression that these methods/technologies are still not available.

She also seems to take Exxon to task for posing the unspoken punch line or question, Why is not the U.S. using nuclear power to build its bridge to the future? Whether or not that is the Exxon intended punch line, I believe it is an excellent question that we should all truly endeavor to answer.

Michael J. Mulcahy
Brookline, Mass.

Centrifuge Out of Control?

Alexander Klibanov writes an accurate, lucid, and most readable exposition of a complex and important topic (*"Enzymes: Nature's Chemical Machines," November/December, pp. 40-50*). But recollections of my years in an early enzyme industry—yeast—suggest to me that the captions on the photographs on your pages 43 and 44 may have been transposed.

Frederic W. Nordsiek
Chapel Hill, N.C.

Reader Nordsiek is quite correct, and the editors red-faced at their inability to distinguish between fermenters and centrifuges.—Ed.

The Little Engine That Does

BY TOM SHEDD

American railroads face tough new competition in the freight-carrying business. One way they are competing is by upgrading their symbol of efficiency—the diesel-electric locomotive.

ALTHOUGH the days are long past when railroads were synonymous with intercity passenger travel, the locomotive still plays an essential role in the U.S. economy. Railroads remain easily the largest carriers of intercity freight: in 1982, they moved a total of 812 billion ton-miles, representing 36.3 percent of the overall transportation volume. By contrast, trucks hauled 22.7 percent, pipelines 24 percent, barges and other water-based carriers 16.8 percent, and airplanes just 0.2 percent.

Clearly the railroads remain indispensable underpinnings for many key industries that need to move large amounts of raw materials or finished products over long distances, such as steel, automobiles, agriculture, and chemicals. But the basic parameters of freight transportation are changing rapidly, and to survive the railroads have had to adapt.

During the past decade, in fact, the railroads have had to cope with almost as many changes, both direct and indirect, as they encountered in their first 150 years. The partial deregulation of the railroads in late 1980 freed them to exercise more marketing initiative and concentrate on what they do best—move large amounts of heavy commodities over long distances. Recent mergers have reduced the number of major railroads and have served to concentrate more of the traffic on the most important, and economically efficient, routes. Within this decade, the United States will probably end up with fewer than half a dozen large independent systems, some extending from coast to coast.

Meanwhile, the competitive struggle between railroads and other forms of transportation has intensified. The near-completion of the interstate

PHOTO: ELECTRO-MOTIVE DIVISION, G.M. CORP.

During the decade ending in 1982, major railroads gained 24 percent in fuel efficiency.

highway system and the steady growth of the size and capacity of tractor-trailers have strengthened the trucking industry's dominance in hauling general freight. Barges now battle railroads for the right to carry bulk commodities; slurry pipelines threaten to compete in the future.

Further deregulation of freight-haulage, which went into effect in 1981, has led to spectacular growth in "intermodal traffic"—primarily truck trailers that travel piggyback on flatcars. Intermodal represents the railroads' only realistic opportunity to share in the huge market for moving merchandise and other general freight. To compete with highway trucking, however, piggyback train service must be fast, frequent, and totally reliable.

The factor that has had—and continues to have—the most profound effect on the railroads' technology for motive power has been the soaring increase in the cost of diesel fuel. Until the Arab oil embargo of 1973-74, most railroads didn't worry too much about the cost of locomotive fuel. But like the proverbial 2-by-4 to the head of the mule, the tenfold increase in the price of diesel oil in the last decade has gained the attention of everyone in the industry—railroad executives, locomotive builders, and the suppliers of components and accessories.

It's not hard to understand why. In 1982, diesel fuel cost the class-1 railroads—the large systems that comprise about 95 percent of the industry—$3.1 billion, or more than 11 percent of operating revenues. In typical pre-embargo years, by contrast, fuel cost less than 4 percent of revenues. By the early 1980s, in fact, fuel expenditures rivaled the total wages of train and engine crews, which have traditionally been the major item in railroad expenses. The cost of fuel substantially exceeded the amount of capital that the industry was able to invest in physical improvements. In 1982 fuel costs exceeded four times the industry's total operating profit.

The oil embargo set off a period of sustained research and development that has touched on every aspect of the railroads' operations. During the decade ending in 1982, the class-1 lines achieved a gain of 24 percent in the ton-miles of freight carried for revenue per gallon of fuel consumed.

The improvement has come about in several ways. The industry has begun to understand the importance of reducing the weight of cars to allow them to carry more freight. Improved wheel suspensions are reducing fuel consumption, particularly over curved track. Better aerodynamics, especially streamlining for piggyback equipment, are saving significant amounts of fuel at the high speeds necessary to keep railroad service competitive with trucking.

The High-Efficiency Engine

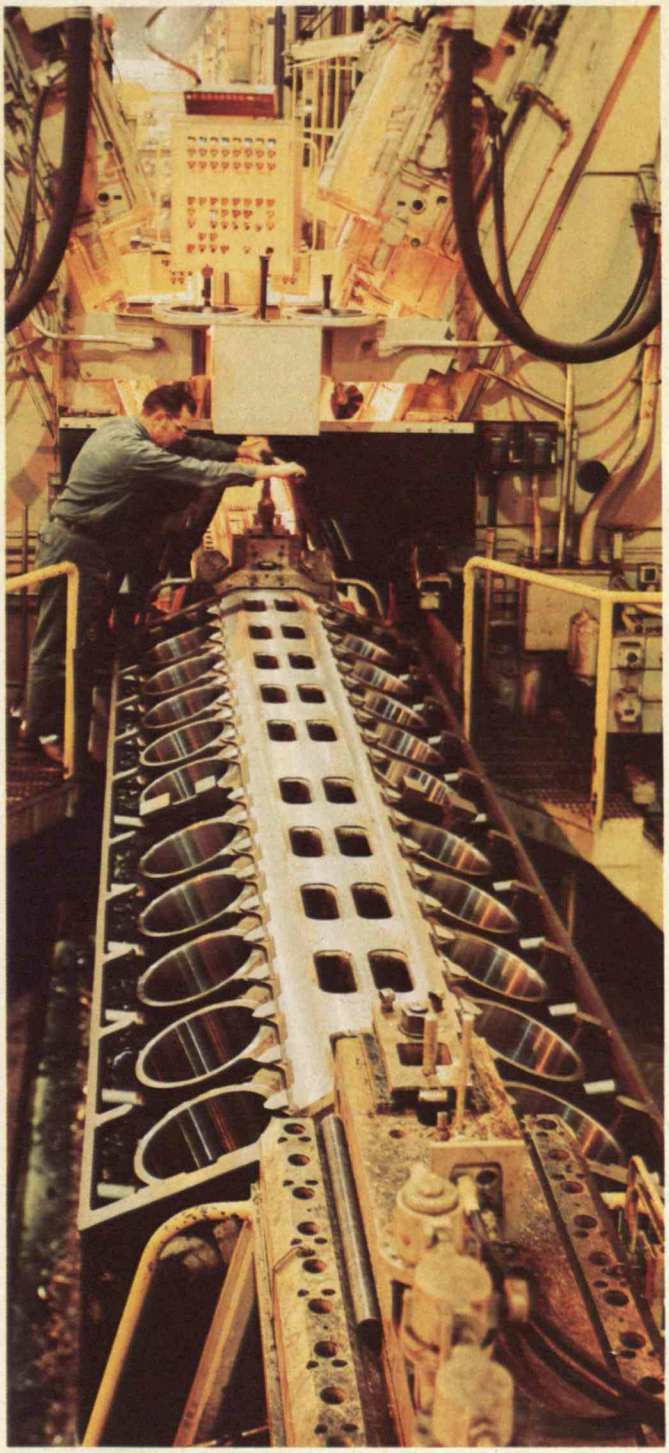
The main efforts of railroads to improve fuel consumption, however, have focused on the diesel-electric locomotive—a machine that replaced the steam locomotive three decades ago because of its high efficiency. The diesel is actually an electric locomotive with its own self-contained power-generating equipment. It gives railroads most of the benefits of electrification without requiring any of the capital costs of installing contact wires or third rails.

Diesel locomotives initially hauled high-speed mainline passenger trains in the 1930s. After World War II, the railroads began the rapid conversion of all their other operations to diesel propulsion. By 1960, when the number of working steam locomotives had fallen to a mere 250, the class-1 railroads boasted 28,300 diesels—about half the number of steam engines they had in 1929, when the railroads hauled only 78 percent as much freight.

It is worth emphasizing that the diesel took over because of sound economic and operational advantages—though the process of conversion was undoubtedly hastened by the marketing expertise of the locomotive builders, most notably General Motors. The diesel was simply a superior product—a form of motive power that met the railroads' needs better than existing steam locomotives. Even the early diesels converted power into traction four times more efficiently than steam engines. The diesels could run many hundreds of miles without refueling or maintenance, while steam locomotives had to stop every 100 to 200 miles for fuel, water, lubrication, and other attention. Diesels had less downtime, required fewer service and repair shops, needed far fewer people to keep them running, and caused less damage to the tracks.

They also evolved. As the railroads began to drop out of the passenger business and concentrate on running longer, heavier freight trains, they gradually replaced their first-generation diesels with more powerful, heavier, slower, and more utilitarian units. Locomotives with 3,600 horsepower are common

Continued on page 66



Diesel power has become the mainstay of the railroads. Highly efficient at converting electric power into traction, and able to run hundreds of miles without refueling or maintenance, diesel locomotives took over from steam power in the 1950s. Modern diesel units pack more than twice as much power as early diesels, allowing them to haul long, heavy freight trains (left). Locomotive manufacturers are also improving their manufacturing methods. The photograph at right shows a diesel locomotive crankcase being machined under computer control.

PHOTOS: SANTA FE RAILWAY; ELECTRO-MOTIVE DIVISION, G.M. CORP.

Keeping the Railroads on Track

BY JOHN R. MEYER

CAN U.S. railroads maintain their present prosperity? What sort of future do they face in a world of increasingly tough competition? What strategic choices will determine their future? These are the vital questions confronting railroad executives as they plot the course of their industry after a five-year period dominated by deregulation and unprecedented economic turbulence.

In many ways, the railroads now enjoy the best of times. Their balance sheets are not awash in red ink, as they have all too often been in the past, and their efficiency is higher than ever. Because of massive investments in new equipment and facilities, the railroads can now produce at least as many revenue ton-miles as they did in their halcyon days of all-out effort during World War II, with only about one-fourth as many workers. Railroading is a part of the old industrial complex that is now truly "lean and mean."

The issue now is whether the newfound prosperity is permanent, or merely a blip on the chart that will disappear as structural problems drag the railroads down to the depressing levels of past years.

One major cause for concern among railroads is what will happen to their customers in smokestack America—the traditional manufacturing industries, many of which are slowly dying from the twin impact of cheap foreign labor and domestic high technology. Over the past century, smokestack industries have developed a symbiotic relationship with the railroads. When the industrial centers prospered, so did the railroads that served them. Thus, they could become partners in decline.

Heavy industry continues to be a primary user of rail transport, particularly in gathering its raw materials. Metallic ores, the mineral trona, and bulk chemicals fill freight cars by the million. The Northeast in particular maintains the traditional link between railroads and heavy industry. The Pennsylvania Railroad, for example, was largely built to serve the steel industry.

But the railroads do not depend entirely on smokestack America. Many railroads, particularly those in the West, hardly felt the impact of the recession of 1974-75, which seriously eroded many manufacturing industries. Two commodities helped the railroads to roll smoothly through that crisis. The large sales of U.S. grain to the Soviet Union, and the increasing substitution of coal for imported oil as a primary source of energy, kept the freight trains running during the middle and late 1970s at a frequency far greater than would otherwise have been the case.

Will the railroads shrug off the effects of the "great recession" of 1981-92 as effectively? To determine that, and discover how seriously structural problems threaten the railroads, we must examine their underlying traffic trends and cost relationships.

Bad and Good News

We can best grasp the traffic trends by comparing factory production with railroad traffic in various industrial categories. The comparison shows two definite patterns.

The bad news is that, for most manufactured products, output has expanded more slowly than gross national product. Also, the railroads' market share of the available traffic has declined consistently over the past several decades. There are two major exceptions. The railroads have roughly held their share of automobile deliveries over the past two decades, despite some weaknesses during the latest recession. And piggyback traffic on railroads has grown; in fact, it has increased at a faster rate than industrial production. This growth, however, has not been enough to offset all the declines elsewhere—particularly in boxcar traffic, which has been cannibalized to some extent to create the gains in container traffic.

Next, the almost-good news: railroads have more or less retained their market shares in most bulk commodities. For example, rail carloads and tonnage of farm products (mostly grains), metallic ores, chemicals, primary metal products, and pulp, paper, and allied products either remained stable or actually increased during the second half of the 1970s. By contrast, rail-carried volumes of machinery, fabricated metal products, petroleum, nonmetallic minerals and stone, clay, and glass all fell, some significantly. While most of these bulk-commodity industries have not grown as rapidly as the economy as a whole, some have expanded. And in the last ten years, of course, one bulk commodity—coal—has increased output more rapidly than the general economy. As a result, railroad tonnage of coal rose by over 25 percent between 1975 and 1980.

Market share is intimately connected with costs, a link that took on added significance in 1980 with the passage of the Staggers Act and the Motor Carrier Reform Act. These two pieces of legislation largely deregulated the railroad and trucking industries, respectively, even though the exact scope of the deregulation remains to be defined. Without doubt, though, neither trucking nor railroading will ever be quite the same again.

As a result, a series of basic questions can be asked: Do the railroads possess basic cost advantages that will enable them, using their new freedom under the Staggers

PHOTO: SANTA FE RAILWAY

Act, to recapture some of the market share that they have lost to trucks over the years? Put more rhetorically, are not the railroads less labor- and energy-intensive than truckers, and therefore more likely to reap competitive advantages from prospective long-term increases in the costs of labor and fuel? Furthermore, haven't the railroads outpaced the truckers in improving productivity over the past several decades, so that they will reap additional cost advantages over time?

Ambiguous Advantages

The answers are neither obvious nor easy—and from the railroads' point of view they are not necessarily encouraging. The railroads' advantage over trucks is more apparent than real, owing to the nature of the trucking business. And while the railroads are indeed slightly less energy-intensive than trucks—through a combination of inherent advantages and newly introduced technology—that fact may not prove significant over the next decade or so, owing to the likely trend of fuel prices.

The cost advantages over trucks that railroads enjoy on paper disappear when one compares railroads with the sector of the trucking industry with which they compete directly. Labor costs for common-carrier truckers do run at about 60 percent of operating costs—roughly 10 percent higher than the railroads' figure. Unfortunately, the railroads' direct competition comes not from the common carriers but from private and independent truckers, whose labor costs range from 20 to 45 percent of total costs.

Other labor factors give the railroads added cause for gloom. The teamsters have recently settled for substantially lower wage increases than railroad workers. And while both industries have problems with pensions, the railroads are likely to suffer more. About 400,000 working railroaders now support more than 1 million retirees. In the trucking industry the ratio is just the reverse, with roughly 3 active workers for every 1 on pension. Furthermore, small private trucking companies have an option not really open to the railroads: they can go bankrupt, and transfer their pension burden to the federal government.

As for energy costs, forecasters increasingly contend that the price of petroleum will remain constant for the next five to ten years. That means that the real price of diesel fuel and gasoline, adjusted for inflation, will decline. If that is the case, then trucking costs will fall over the next few years *relative* to those of rail, because trucks are more energy-intensive.

Even the railroads' record of productivity has not much exceeded that of trucking. The labor productivity of railroads has risen by about 3.7 percent annually since World War II, in contrast to the 2.0 to 3.1 percent figure for trucking. However, the total productivity of both modes—counting capital as well as labor—seems to have increased by about 2 percent per year during the last 20 to 30 years. And recent highway legislation grants truckers scope for improving productivity considerably. Not only do they have better roads, but they can now drive in larger trucks, without interruption in transcontinental hauls.

Overall, then, the railroads' superiority in the oncoming free-for-all of a deregulated surface-freight industry is hardly guaranteed. In fact, one can make as good a case for the truckers as for the railroads, especially in hauling high-value freight.

Given this climate, the railroads face some complex strategic choices. There seem to be two primary options:

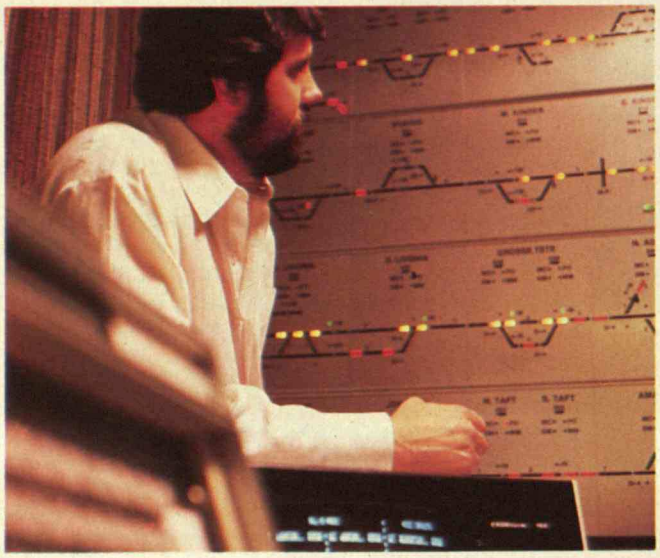
□ Retreat into hauling mainly bulk commodities, offering customers contract rates and using unit trains that take only one commodity, while continuing to play merely an "end game" with manufactured traffic in boxcars and containers.

□ Advance into an attempt to run two very different operations side by side. One would consist of unit trains hauling bulk commodities under contract rates. The other would concentrate on manufactured goods in containers, moved relatively fast by short trains with one- to three-person crews.

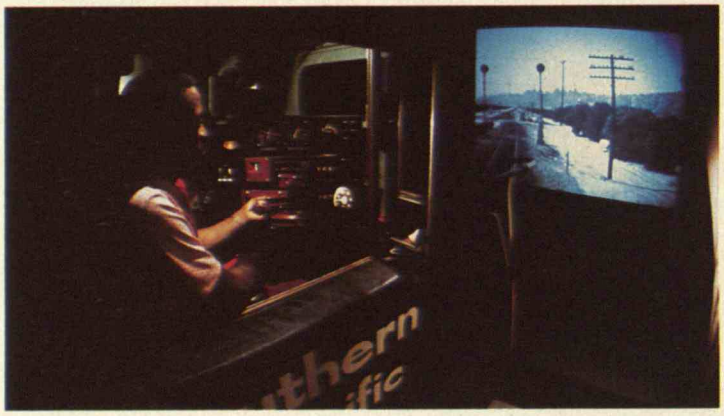
Clearly the second option is by far the more promising, but it is also far more difficult. It requires that the railroads establish a new relationship with labor. It requires a thorough reevaluation of management procedures and thinking. And it carries no guarantees that it will work, since it moves against the basic traffic and economic trends. Nevertheless if—and it is a very big if—the railroads are to move ahead in the next two decades, they really have no alternative. □

JOHN R. MEYER is James W. Harpel Professor of Capital Formation and Economic Growth at Harvard's John F. Kennedy School of Government. He served as vice-chairman of Union Pacific Corp. from 1981 to 1983.

"A heavy-duty locomotive can use $300,000 to $400,000 worth of fuel annually."



Train dispatchers and engineers can improve railroads' efficiency considerably. Dispatchers (above left and right) can ensure that trains arrive at their meeting points right on schedule.



Engineers affect their vehicles' fuel consumption just as surely as car drivers. Locomotive simulators (left) teach engineers to handle their locomotives as efficiently as possible.

today; 30 years ago, the typical freight units had a rating of 1,500 horsepower.

Electrical components produced much of the improvement. Better insulation allows present-day motors to handle twice as much power as those of 30 years ago without any increase in size. Alternators whose output is converted from alternating current before feeding into the direct-current traction motor have replaced direct-current generators; they provide more capacity in the same volume and cost less to maintain.

A Series of Small Improvements

Those changes in diesel technology were largely established by the time of the Arab oil embargo. The spectacular improvements in diesel fuel economy since then have come about not through one or two major technological advances, but via a series of small gains. Max Ephraim, Jr., chief engineer of the Electro-Motive Division (EMD) of General Motors, stressed the basic approach at a conference on railroad energy technology in Memphis, Tenn. "Every aspect of engine and locomotive design must be carefully considered," he declared. "A heavy-duty locomotive can use $300,000 to $400,000 worth of fuel annually. Even a fraction of 1 percent improvement in locomotive efficiency can mean an annual saving of thousands of dollars per locomotive unit."

EMD has incorporated a dozen or more fuel-efficiency improvements into its current diesels. A better turbocharger to increase pressure in the engine, larger-diameter injectors to introduce fuel faster into the combustion chambers, and a higher compression ratio all enable the system to burn fuel more completely. A lower idle speed means that locomotives

PHOTOS: UNION SWITCH & SIGNAL; SOUTHERN PACIFIC

Hot-rodding engineers who open the throttle wide and then apply the brakes hard at the last minute waste fuel.

use less fuel when they are just standing by. Smaller motors in the radiator fans consume less energy when cooling the engine. Two-speed fan motors also require less energy, because the lower speed can often be used. Reducing the flow of cooling air to the traction motors—through minor changes in the design of air ducts and motors—and increasing the efficiency of the alternator obviously decrease fuel usage. Alterations that allow the engine to run more slowly during dynamic braking—the process during which motors are used as generators to hold back the train on descending grades—have also reduced the consumption of diesel fuel.

None of these improvements is particularly significant when considered alone. Together, however, they have reduced fuel consumption on EMD's locomotives by 10 percent during the past five years. The other major U.S. builder of diesel locomotives, General Electric, has built up its own impressive record through similar improvements. The company claims gains in fuel efficiency ranging from 6 to 14 percent, according to the particular model of locomotive, over the last five years.

A vital factor in a locomotive's efficiency is its ability to develop high adhesion between its wheels and the rails. This is particularly important for locomotives that must drag heavy trains up ascending grades. The cabs of early diesels contained an indicator that sounded an alarm when the wheels started to slip; the engineer could then apply sand to the rails and/or reduce the power to the traction motors. Today's more sophisticated controls take the two remedial actions automatically when the wheels begin to slip. And the controls act only on the particular pair of wheels that is slipping instead of on the locomotive's entire set of wheels.

The latest attempt by EMD to control slipping wheels stems from laboratory work at the Illinois Institute of Technology and field studies using instrumented locomotives. According to the tests, the maximum adhesion between wheel and rail occurs when the value of what engineers call wheel creep exceeds 2 percent. Hence, maximum adhesion happens when the wheel travels more than 102 percent of the distance achieved by the locomotive, as the wheel slips over 2 percent. Following up on this understanding, EMD designers have adapted their control systems to allow the wheels to creep under controlled conditions to produce the maxium adhesion between wheels and rails.

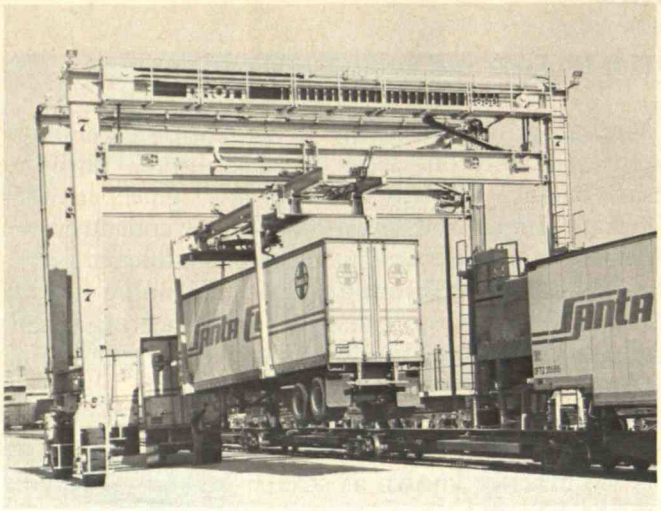
Hot-Rodders and Dedicated Dispatchers

Mechanical improvements in locomotive technology represent only one facet of the railroads' effort to save energy. The way in which an engineer handles a train affects the locomotive's fuel consumption, just as an automobile driver's habits influence a car's gas mileage. Accelerating gradually, running steadily at the lowest speed consistent with meeting schedules, and thinking ahead when approaching stopping points all save diesel fuel. Hot-rodding engineers who open the throttle wide and then apply the brakes hard at the last minute waste it. Another fuel loser is the practice known as stretch braking—applying the brakes while the locomotive is under power when the train is moving along undulating sections of track. Railroads are strenuously training their crews, both in simulators and on real locomotives, to avoid stretch braking whenever possible. A few railroads have installed devices that resemble flight recorders on their locomotives. These enable supervisors to pinpoint particular locomotives, sections of line, and engine crews that need special attention.

Some railroads have also reduced operating speeds to save fuel. Although that strategy is effective, it has at least three drawbacks. While coal-carrying trains, for example, can profitably run at about 35 miles per hour, piggyback trains may require speeds of 60 to 70 miles per hour to stay competitive with trucks. When trains spend longer on the road, labor costs increase. And poorer utilization of the equipment adds to interest costs, which can amount to $100 per hour for a single train with three locomotives and 100 cars.

The train dispatcher is often the key to fuel-efficient operation of a rail line. With the whole picture of the trains on a railroad on the control panel, and a knowledge of the destination, weight, and contents of each train, the dispatcher can instruct each engineer to run at a specific speed, to ensure that the train arrives at its meeting points with other trains exactly on time. The dispatcher must also assign enough locomotive power to each train to enable it to run on schedule while using the minimum number of locomotive units. Experienced dispatchers know, and factor into their calculations, the habits and capabilities of each individual engineer.

Canadian National (CN), to mention one railroad, now uses computer-aided dispatching, which does many of the dispatching chores automatically. CN



and other railroads are working toward automatic train dispatching, in which the computer carries out all the tasks and the dispatcher has to intervene only when the system goes down.

Searching for Alternatives

Beyond stimulating a series of technological refinements in locomotive design and handling, the rising price of diesel oil brought to the fore an old question: Can the locomotive diesel engine run successfully on different, less expensive fuel? Several railroads experimented with residuals and other low-grade fuels in the 1950s and 1960s. But with the standard number-2 diesel fuel costing less than 10 cents per gallon at the time, they had little economic incentive to use substitutes. The situation is considerably different today, even though the price of diesel fuel has dropped appreciably below its 1982 peak of $1.05 per gallon. Railroaders have two good reasons for investigating alternative fuels. They would like to know what sources of fuel they can use in an emergency if petroleum supplies are again restricted; and they hope to develop fuels to supplement or replace number-2 diesel, as it becomes more expensive and scarce.

Researchers at the Southwest Research Institute in San Antonio are looking at three broad alternatives in a program sponsored by the Association of American Railroads. One is the class known as "off-specification distillates"—fuels that offer less power than the standard diesel variety. Another class consists of alcohols, vegetable oils, powdered coal, and distillate from shale, tar sands, or coal. Finally come the hybrids: emulsions of diesel fuel and water or

alcohol, and slurries of carbon and diesel fuel.

So far, research has proven that diesels can run on a number of alternate fuels. Synthetic crude oils seem to give the best performance. But whether alternates can really compete with diesel fuel remains uncertain. Some alternative fuels contain impurities, such as manganese and ash, that would increase maintenance costs. With others, the diesel engine does not start easily or run smoothly enough. According to T.N. Pratt of EMD, petroleum distillates will continue to predominate as railroad fuels for years to come. But their quality will gradually fall and prices will rise, making synthetic crudes from shale or tar sands, and distillates derived from coal, increasingly attractive toward the end of the century.

If railroad executives are considering alternative fuels, can other types of locomotive power be far behind? In fact, railroads have already tried nondiesel locomotives. Union Pacific operated a number of oil- and coal-fired gas-turbine electric locomotives in the 1950s and 1960s, and U.S. and Canadian railroads have run passenger trains powered by aircraft-type gas-turbine engines. Engineers at the Jet Propulsion Laboratory have studied the possibility

Piggyback train service, in which truck trailers are hoisted onto flatcars for long-distance runs (far left), gives railroads the opportunity to compete directly with truckers. However, piggyback trains must run faster than 60 miles per hour, on average, to remain competitive. In general, the railroads' lineup of diesel power (near left) is more suited to hauling loads such as coal, which can be carried profitably at 35 miles per hour.

of using the adiabatic diesel engine, which eliminates the cooling system and uses energy in exhaust gases. Other schemes include resurrecting the Stirling engine—an external-combustion system invented in 1816 that can, in theory, burn any type of fuel—and designing new coal-powered locomotives.

These proposals have so far generated little enthusiasm among railroad officials. The reasons are obvious. Coal-fired locomotives would need a complete new support structure, including coaling and watering stations and maintenance shops. Even electrification, a more feasible way of using coal energy that is already in small-scale operation, short-circuits on the ground of huge capital requirements—although it seems likely to be adopted for some of the most heavily used freight lines by the end of the century.

The Era of Diesel Dominance

Overall, the diesel-electric locomotive seems certain to remain the dominant form of railroad motive power in North America, at least until the year 2000. But just as diesels have evolved considerably over their first 50 years, they promise to continue to change in the next few decades. Bombardier, Inc., the Montreal-based company, is now testing a diesel locomotive that uses alternating-current traction motors. They are more rugged and more easily maintained than the conventional direct-current motors, and can develop more power in the same-sized package. EMD and General Electric have both introduced computer-aided design techniques, and plan soon to market new locomotives that feature microprocessor-based controls. The controls will increase the reliability of locomotives, in part by reducing the need for mechanical relays. New controls will also make trouble-shooting simpler and thus keep locomotives on line more of the time.

Not too far in the future is the likelihood of computerizing the actual operation of locomotives and their handling of trains. In fact, high-speed passenger lines in Japan are already using computerized trains. On-board computers, fed with data on the motive power, characteristics of the train, and nature of the road-bed, run the trains with little intervention from engineers.

Diesel-electrics that will become available in the next few years will therefore have adapted to the new environment of more costly fuel. They will be more reliable. They will be able to haul heavier loads faster, when necessary. And they will be able to reduce fuel costs further through an enhanced ability to burn alternative fuels. The diesel that pulled propulsion technology up from its nineteenth-century roots will continue to haul it reliably into the twenty-first century.

TOM SHEDD is editorial director of Modern Railroads *magazine.*

PHOTOS: SANTA FE RAILWAY

Why Not Sell Technology to the Russians?

BY MARSHALL GOLDMAN

The Soviets do not harness Western technology as effectively as once believed. Therefore, restricting East-West trade often hurts the United States as much as it hurts the Soviets.

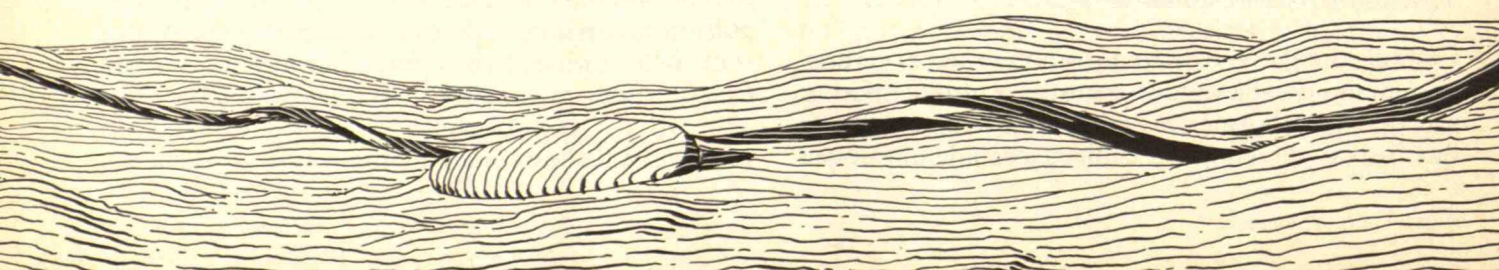
In 1980, Ronald Reagan campaigned for the presidency on a promise to get tough with the Russians—on matters of trade as well as defense. However, in the last year, the Reagan administration seems to have softened its attitude toward the sale of technology to the Soviet Union. Even the downing of the Korean passenger plane last September failed to provoke anything more than impassioned rhetoric from the White House. Although Reagan denounced the shooting as a "heinous act," most of the trade gates to Eastern Europe were kept open.

The debate, however, continues. And in the tumult of a presidential election year, it will only intensify. Should our government authorize, or even tolerate, the sale of technology to a communist country? Should it allow Soviet scientists access to American universities and research materials when so often such access is used to hurt us?

As intense as this debate is in the West, the battle over technology transfer is not unique to the United States and Western Europe. Disputes also arise in the Soviet Union and Eastern Europe over whether to purchase this technology. In both cases, a critical unknown factor complicates the debate: how helpful the transfer of technology is. If the Soviets did successfully absorb Western technology, they could increase not only their military capabilities but their economic productivity as well. But to the extent that the Soviets are unable to digest this technology, such expenditures are not only costly but sometimes generate more problems than they solve. Ultimately, the decision whether to restrict or liberalize sales to the Soviet Union depends on how well the Soviets absorb Western technology.

The biggest fear of Americans who oppose technology transfer is that it will be used to increase

ILLUSTRATION: CHRISTOPHER BING



Soviet military strength, either directly or indirectly. To these critics, the people who sell technology to the Soviet Union are not much different from the U.S. junk dealers who sold steel scrap to the Japanese just before World War II. Naturally enough, most of these opponents come from the Department of Defense. In the eyes of defense officials, the less technology sold to the Soviet Union the better. Why should the United States export machine tools that make precision ball bearings, when those ball bearings might be used to increase the accuracy of Soviet missiles? The few million dollars earned from such sales in no way compensate for the billions of dollars that then must be spent to improve our defense against more accurate missiles. Opponents of such trade also point out that the value of U.S. exports to the Soviet Union totals little more than 1 percent of all U.S. exports. The National Security Council (NSC) supplements these economic arguments with a moral one. NSC officials feel it is indecent and politically embarrassing to sell American products to an "immoral" nation.

The view from the Departments of Commerce and State is more pragmatic and accommodating—or, as their critics say, unprincipled. Commerce officials regard exports as necessary in these days of record-high trade deficits and an overvalued dollar. They believe the Defense Department views everything in strategic terms. And to illustrate just how absurd the defense argument can be, they ask if a strategic trade ban should include buttons—so the soldiers' pants will drop. As the late financier Bernard Baruch put it, "Bubble gum is the only item with no military significance."

Those who favor trade point out that a ban on commercial exports is hard to justify, now that President Reagan and his secretary of agriculture have made such a strong case for the export of grain. How can you export one and not the other? Similarly, Europeans charge that the United States seeks a worldwide ban on the export of technology because the United States is not a strong exporter of that commodity. As the Europeans see it, the United States humiliates itself in its eagerness to sell grain to the Soviet Union because it is the world's leading grain producer. If the United States were a less important grain exporter, the Europeans believe it would seek a ban on grain sales as well.

The proponents of trade argue that a ban on the export of most goods, grain included, often hurts the United States more than it hurts the Soviet Union. More often than not, our refusal to sell means that the Soviet Union simply buys what it wants from someone else. Back in the 1950s, the United States was often the only producer of many vital items. When we refused to sell a machine tool or grain, the Soviet Union generally had nowhere else to turn. Today, it has many alternatives. Before the embargo was imposed to protest the Afghanistan invasion, American grain sales constituted 70 percent of Soviet grain imports. After the embargo, they fell to 17 percent because the Soviet Union had turned to other suppliers.

To compound the damage, our foreign competitors often use a Soviet import order as a stimulus to develop products and technology for their own countries. Thus, the United States not only loses sales to the Soviet Union but soon finds increasing competition in markets it once had for itself. These arguments seem to explain President Reagan's refusal to cancel the grain agreement, or revoke Caterpillar Tractor Co.'s license to export pipe-laying equipment to the Soviet Union, after the downing of the Korean plane.

Many proponents of trade also feel it can be an instrument in generating better relations between the United States and the Soviet Union. Trading partners are not necessarily the best of friends, but trade could be used at least as a small lever in ameliorating Soviet political and international behavior. The threat to withhold trade influenced the Soviet decision in the early 1970s to allow the emigration of Jews, Germans, and Armenians. Later, in an effort to put a speedy end to the 1975 grain embargo, the Soviets decided to hold their tongues and their tanks during Henry Kissinger's negotiations with Israel and Egypt over the withdrawal of Israeli troops from the Sinai. The Soviets were resentful about being excluded from the negotiations, but their need for grain outweighed their need for political involvement. And because the weather was bad in Canada and Argentina, there was nowhere else they could turn. Thus, without trade to suspend, we have one less way to demonstrate anger over Soviet actions.

The Soviet Perspective

Import issues in the Soviet Union are equally complex. Those who favor buying Western goods argue that imported technology is better than domestic

The Soviets have had little success in reproducing the technology they import for their automotive plants. As a result, they tend to fall back on Western suppliers when new plants are needed.

technology. Without imported technology, productivity and quality would be considerably poorer. Without imports, the Soviet Union might not even be able to make such important products as synthetic fibers, modern pesticides, and insecticides. In addition, foreign technology has played a critical role in the production of Soviet automobiles, diesel trucks, television picture tubes, and aluminum and steel smelting. Thus, imported technology has helped to fill gaps not only in high technology but in some of the older and lower-technology sectors such as metallurgy as well. According to Soviet proponents of trade, imported technology can help increase both civilian and military productivity.

Opponents of technology imports in the Soviet Union argue that their country has become overdependent on such goods. Not only does buying them require hard currency, which is scarce, but much of the highly touted technology works badly and sometimes not at all. There are also security considerations. Because Soviet authorities tend to be very secretive, they fear too much interchange with Western technicians. In addition, importing technology tends to divert resources away from research and development within the Soviet Union. Buying Western technology and equipment also leaves the country vulnerable to external pressures.

A decision by Soviet authorities to permit the purchase of Western technology is not one that is made lightly. In fact, in several cases authorization has been granted and then rescinded a short time later. Soviet officials began to import technology on a large scale in the late 1920s, but exports were halted in the early 1930s because of the depression. Imports were increased substantially during World War II when the United States was allied with the Soviets against Germany and Japan, but then were virtually halted in the late 1940s with the beginning of the cold war. Nikita Khrushchev ordered the large-scale purchase of chemical - production equipment in the 1950s, but even by 1960 Soviet imports of machinery still amounted to less than $500 million a year. Although there was a temporary hiatus from 1964 to 1967 after Khrushchev was ousted, imports reached about $1 billion in 1970. They continued to grow rapidly thereafter until 1978, when imports from the West hit a high of about $5.5 billion. Orders of machinery and transportation equipment were sharply curtailed after 1980, reflecting perhaps the resumption of cold war hostilities as well as Soviet disappointment with imported technology. The Soviet dependence on Western technology reflects an inability to generate high-quality production and innovation within the Soviet planning system. We know that Soviet scientists and engineers are capable of impressive work in their laboratories, and on military and space activities. But this work seldom finds its way into factory-produced consumer goods. Even when it does, implementing innovations in the Soviet Union takes about twice as long as in the United States. The best explanation for this is that the managers of factories producing consumer goods are forced to adhere to a system of plans and targets that stresses quantity, not quality. A manager's monthly bonus traditionally depends on whether the factory meets its target for production volume. There is every incentive to avoid new production processes that may increase quality or decrease cost if their adoption jeopardizes this output even temporarily.

Moreover, the rewards for making new products in the Soviet Union are slim. Until recently, it was very difficult to obtain permission to charge a much higher price for a significantly improved product.

PHOTOGRAPHS: TASS/SOVFOTO

Only in August of 1983 were managers told they could raise wholesale prices as much as 30 percent for such new products. However, Soviet authorities continue to believe that the best way to increase innovation is simply to decree that it should take place. That certainly is the impression from the official government statement of last August, entitled "On Measures to Accelerate Scientific and Technical Progress in the National Economy." Unfortunately, such decrees involve little more than exhortation, and seem little different from scores of similar decrees issued since the 1930s—almost all of which resulted in no significant increase in production, productivity, or innovation. Although the most recent decree attempts to stimulate innovation, it contains nothing to induce factory managers to alter entrenched patterns of behavior.

The Catch-22 of Soviet Policy

Basically, Soviet factory managers are in a bind. On one hand, they know that little high-quality production equipment can be obtained within the Soviet Union. At the same time, they are under considerable pressure to produce higher-quality products. It is not surprising, then, that Soviet managers have been tempted to fall back on imports. When Khrushchev decided he needed more fertilizer to increase agricultural production, he discovered that the Soviet Union lacked the chemical industry to produce that fertilizer. So he ordered Soviet officials to import substantial quantities of chemical equipment that allowed the Soviet Union to produce not only fertilizer but also plastics and synthetic fibers. A few years later, Alexei Kosygin found that he lacked the necessary wherewithal to increase and modernize the Soviet Union's automobile production. So he turned to Italy, the United States, France, and Germany for much of the machinery used to equip the Fiat automobile plant in Togliatti and the diesel truck plant at Kama River. That plant, in fact, was equipped largely by what was once the Swindell Dressler Division of Pullman Co.

Although the precise share is hard to measure, imports of Western technology probably constitute only 1 or 2 percent of the Soviet gross national product. Yet without such imports, the Soviet Union might find itself without a modern chemical and automobile industry. Indeed, the Soviets can point to relatively little new industry developed from within in recent years. More often than not, the technology and machinery needed for new industries have been imported from the West; and that often means complete turnkey operations such as the Fiat plant and the Corning Glass plant in Lvov, which produces television picture tubes.

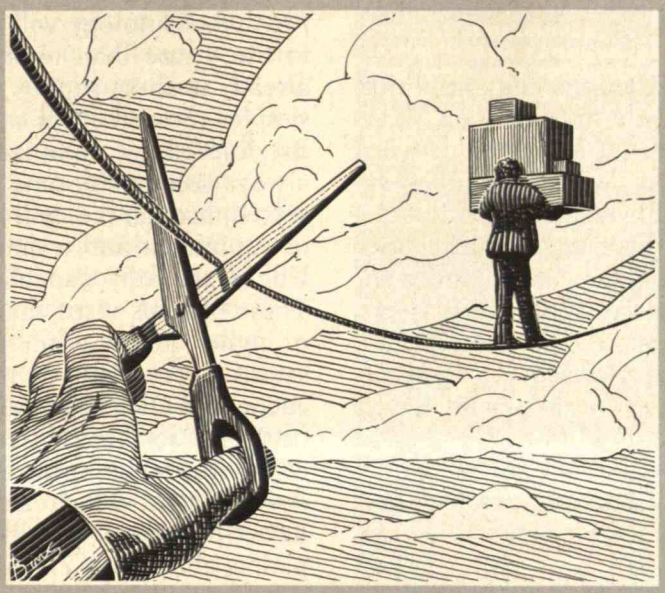
Of course, technology transfer does not depend on the purchase of machinery only. The Soviets also go to great lengths to avail themselves of information in scientific journals, and even in advertising brochures and U.S. congressional testimony. Such information has undoubtedly been important to them, particularly in the military sphere; why else would the Soviets go to such efforts to obtain it? Indeed, prior to the late 1950s and 1960s, the Soviets relied almost solely on this tactic of "reverse engineering." They reasoned that it would be cheaper for them to obtain documentation of a technology and perhaps a prototype or two rather than to spend the money necessary to buy an entire facility. But by 1966 Kosygin had concluded that reinventing the wheel had proven to be very wasteful. While the Soviets had little difficulty understanding technical innovations in Western literature, they were slow to translate these innovations into more efficient production systems because of scanty management incentives. Kosygin decided it would be cheaper and faster to buy complete processing facilities directly from the West.

This seeming inability of Soviet planners to provide equipment and know-how for new industries should give pause to those who argue about how much the Soviet Union's domestic economy stands to gain from cutbacks in military expenditures. All the available evidence suggests that Soviet planners would have difficulty converting their swords into plowshares, not to mention digital watches and hi-fi sets. For example, Nicholas Grant of M.I.T. has pointed out that the mills that produce the heavy plate steel used in Soviet military equipment cannot easily or cheaply be rerouted for civilian uses. Soviet automobiles are heavy, but not that heavy. To obtain the kind of sheet steel required for automobile and appliances, the Soviets would have to build entirely new steel mills. Since the Soviets specialize only in the heavier kinds of steel, they may have to fall back on foreign help in building new steel mills. Presumably, existing mills would also have to be closed down, meaning large-scale unemployment for the first time in recent Soviet history.

(Continued on page 76)

The Debate over Export Controls

BY RICHARD CORRIGAN



THE Export Administration Act is coming up for renewal again in Congress, presaging an election-year tussle between administration advocates of tight controls and congressional supporters of increased export sales.

The current Export Administration Act, passed in 1979, gives the president the authority to refuse an export license for any item on his list of sensitive goods. Without such a license, an overseas transaction cannot legally take place; a violation could lead to criminal penalties and various sanctions, including a prohibition on future export sales. The law is designed to control the flow of U.S. civilian goods to potential adversaries who might put these items to military use. (Exports of military hardware and nuclear technology, which pose an immediate threat to national security, are covered by other laws.)

To the administration's dismay, Congress was moving to ease these export controls when its 1983 session came to a close last fall. Spurred by a coalition of business groups, the House passed a revised version of the act that would restrict presidential authority over export sales. The Senate was working on a comparable bill when time ran out. Congress agreed to extend the current statute (which would have expired last October) through February of this year, so the administration could retain its regulatory powers between sessions.

A Foreign-Policy Tool

Although the Reagan administration uses the Export Administration Act primarily to control the sale of technology to Soviet-bloc nations, the law can also be used to restrict sales to nations found to be fomenting international terrorism—namely Libya, Syria, South Yemen, and Cuba. It can also be used as a foreign-policy tool against nations that violate human rights. The House, in its pending revision of the law, has taken special aim at the apartheid policies of South Africa. Its bill lists a number of economic sanctions, including a ban on imports of South Africa's gold Krugerrand coins.

In the judgment of the House Foreign Affairs Committee, which drafted most of the House-passed bill, the current export-control system is overly restrictive and not very effective. The committee found that the system has cost the United States money and jobs without really curbing the Soviet Union's acquisition of sensitive technologies.

For example, an American firm, the Caterpillar Tractor Co., once had 85 percent of the market on sales of pipelaying tractors to the Soviet Union. But after the U.S. government refused to license the sale of Caterpillar tractors to the Soviet Union in 1978 and 1980 for foreign-policy reasons, the Soviets turned to Komatsu Ltd. in Japan for similar equipment. As a result, Komatsu has acquired nearly 100 percent of the market, according to a business coalition lobbying against export controls. In a letter to all U.S. senators, the business group said that if Caterpillar had been able to retain its market position, "as much as $500 million of additional U.S. exports and 15,000 man-years of U.S. employment would have been generated." Furthermore, critics contend that most technologies that could aid the Soviets militarily have found their way into Soviet hands through illegal means or through non-U.S. sources. Meanwhile, legitimate worldwide trade has been needlessly interrupted.

The Long Arm of the U.S.

The House committee also said in its report on the bill, "These controls have created a pervasive belief" among foreign manufacturers "that U.S. firms cannot be relied upon" to deliver on sales contracts because the U.S. government may decide to squelch a sale for foreign-policy reasons. Their fears are not unfounded. To prevent the Soviets from building a natural-gas pipeline to Western Europe in 1982, the Reagan administration imposed sanctions against eight European companies, including a French subsidiary of Dresser Industries of Dallas, because they were supplying parts for the pipeline. The sanctions prohibited American companies from selling equipment to the eight firms on the administration's blacklist. Those actions sparked a major protest from our allies, and the Russians got the equipment they needed anyway to finish the pipeline. But the whole episode left a bitter taste in the mouths of our allies, and Congress has begun to question the extent to which the U.S. government should go in controlling export sales by other countries. "No other country [outside the Communist bloc] attempts to impose export controls extraterritorily to the extent that the United States does," the House committee said in its report.

The House bill would loosen several key provisions of the export act to speed up the granting of export licenses. For example, the revised bill would permit multiple shipments of goods and services to be authorized instead of requiring separate licenses for each transaction. It would also prohibit blanket export controls on microprocessors. At the same time, the bill would strengthen the enforcement process, making it more difficult for sensitive technol-

(Continued on page 76)

ILLUSTRATION: CHRISTOPHER BING

Fighting the Import Habit

Not everyone in the Soviet Union is convinced that the Soviet economy should rely so heavily on Western technology. Some critics go so far as to warn that buying technology from Western sources exposes the Soviet Union to subversion and sabotage. At the least, foreign suppliers have a much better idea of where Soviet factories are located and what kind of machinery is being used. With this in mind, the late first deputy chairman of the KGB, S. Tsvigin, warned about the danger of increasing contact between foreign business representatives and Soviet officials.

Other critics complained that the Soviet Union was paying too much for technology that at best would soon become obsolete. Moreover, the raw materials that the Soviet Union must export to pay for this technology will probably be more valuable in the future than today. And these resources are already in short supply. Other arguments are much simpler. Soviet officials, including the late Leonid Brezhnev, have complained that factory managers always seem to assume that their problems can be solved through the "purchase from foreign countries of equipment and technology that we in the Soviet Union are fully capable of producing ourselves." These officials insist that Soviet technology is often of higher quality. Others such as Alexandr P. Aleksandrov, president of the Soviet Academy of Sciences, and Oleg Bogomolov, director of the Institute of World Socialist Systems, believe that placing orders with foreign firms hampers Soviet research and development, which already lags behind Western R&D programs. Finally, there are countless complaints about how expensive imported equipment is

THE DEBATE OVER EXPORT CONTROLS

ogies to be sold illegally to the Soviet Union. For example, it would give clear statutory authority to the U.S. government to control the sale of technology within the United States to embassies and affiliates of Soviet-bloc nations.

The Senate version, as reported by the Banking, Housing, and Urban Affairs Committee, would retain somewhat stronger controls on export sales. Yet it, too, represents a less-restrictive approach than that sought by the Reagan administration. In light of the U.S. balance-of-trade deficit and free-wheeling competition in world markets, the Senate committee believes it is "more important than ever" that the export-control system be made simpler and speedier.

Ironically, the Senate bill goes beyond the House version in attempting to prevent business contracts from being overturned by presidential intervention. The Senate bill would make it much more difficult for the administration to halt an export transaction once the contract has been signed.

Blue-Chip Lobbyists

The rewriting of this legislation has been pushed by an ad hoc assembly called The Business Group on the Export Administration Act. Its blue-chip members include the U.S. Chamber of Commerce, the National Association of Manufacturers, the Business Roundtable, the Computer and Business Equipment Manufacturers Association, the National Wheat Growers Association, and the National Grange, among others.

This group's lobbying campaign is likely to impress members of Congress, especially in an election year, when political concerns about the state of the economy and unemployment reach their peak. Barring a serious escalation in East-West tensions, members of Congress appear more alarmed about the potential loss of home-state export deals than about the preservation of the Export Administration Act's intricate safeguards.

Facing a rebellion in Congress over its hard-line approach to export controls, the administration has been seeking stronger multinational controls as an alternative to its unilateral initiatives. Administration officials are now negotiating with U.S. allies to achieve a more coherent, coordinated approach to export controls. Such controls are being discussed with the Coordinating Committee on Multilateral Export Controls, which represents a group of Western industrial nations and Japan.

However, some administration officials are leery of turning over enforcement authority to this multinational group, fearing that controls would be handled too casually to suit U.S. security interests. Under the current system, the Defense Department is allowed to review export licenses before they are granted by the Commerce Department. This enables defense officials to keep track of the destination of any export. These officials are concerned that if controls are shifted to a multinational group, they will not be able to maintain a "paper trail" of exports and reexports.

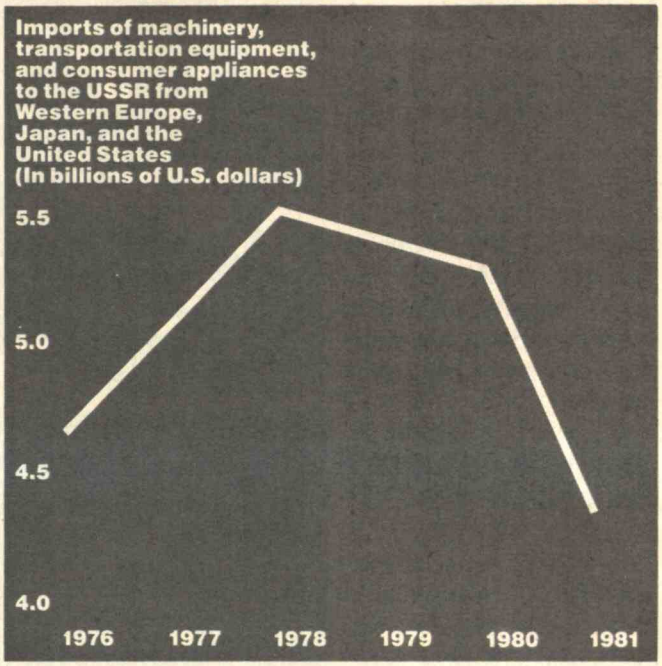
However, the administration may be forced to extend more trust to its allies, because Congress appears ready to crimp its unilateral powers over export sales. If the Senate bill is passed during the current session of Congress, a House-Senate commitee would meet to seek agreement on a compromise version, and a substantially diluted Export Administration Act may become law. □

RICHARD CORRIGAN is a staff correspondent for National Journal, *a Washington weekly on government and politics.*

From the late 1960s through the 1970s, Soviet leaders strongly favored importing Western technology. Imports of machinery, transportation equipment, and appliances grew rapidly, hitting a high point of $5.5 billion in 1978. But after 1980, imports were sharply curtailed, reflecting perhaps the resumption of Cold War hostilities as well as Soviet disappointment with the imported technology.

often used either improperly or not at all. For example, the minister of ferrous metallurgy was accused in January 1981 of importing close to $2 billion of equipment that his ministry had not yet installed. However, as far as can be determined, no official action was taken against this minister.

Until the last five years or so, published complaints about overreliance on imports of technology were quite rare. From the late 1960s through the 1970s, Soviet leaders and factory managers all seemed to be in favor of importing technology. The change in tone suggests that the benefits of such imports may not have been as great as the Soviets once thought. Soviet officials initially believed that imports would generate enough exports to offset the hard currency expended on them. And in the meantime, Soviet planners could learn to reproduce the imported goods and production systems. But these expectations have not been met. In fact, growing evidence indicates that the use of Western technology in the Soviet Union and Eastern Europe has been disappointing and even counterproductive.



Poland in Crisis

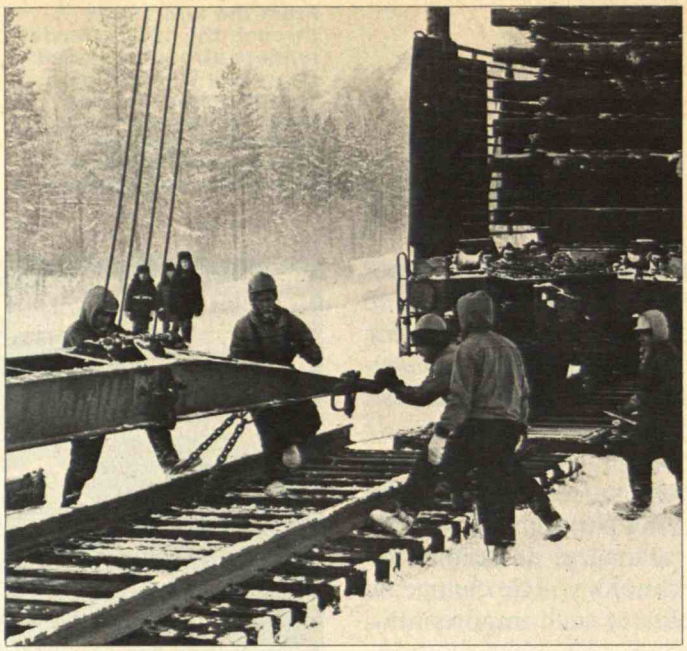
The failure to assimilate imported technology is dramatically illustrated in Poland. The Poles spent millions of dollars in the last decade to import plants for manufacturing tractors, televisions, furniture, and steel. But the raw materials and accessories needed to make these goods were not readily available within Eastern Europe, so these components also had to be purchased from the West. In the mid-1970s, for example, the Poles bought an expensive television-assembly plant from Corning Glass, only to find that elements needed to put together the picture tube had to be imported from the West. The Polish government accepted these risks because it assumed that the hard currency needed to buy the equipment would be offset by the profits from exporting the finished products. But because construction of the plant was delayed, the market had been preempted by Western and Japanese products by the time the Polish televisions were ready. This meant that the exports never took place; instead, televisions with imported components had to be sold inside Poland.

A similar sequence of events occurred when manufacturing plants for tractors and other consumer appliances were bought from the West. Thus, imported technology did not decrease the country's hard-currency debt; it actually increased it. In fact, Poland's inability to master its imported technology, and the resulting escalation of its foreign debt to more than $20 billion, was a major cause of its current economic crisis.

Problems of this magnitude do not show up as readily in the Soviet Union because machinery imports are a much smaller percentage of GNP—1 to 2 percent compared with 5 to 10 percent in Poland. However, the Soviet Union has had similar difficulties. In an effort to build up its ammonia production, for instance, Soviet authorities went out for bids on manufacturing plants from Western companies. The Soviets opted for the lowest bidder, the Chemical Construction Co. (Chemico), a U.S. firm. Unfortunately, the technical feasibility of the project was as low as the bid. Despite spending millons of dollars, the Soviets never produced any ammonia from the project. The plant performed poorly from the start and Chemico itself went bankrupt, so the production facilities could not be improved.

The Soviet purchase of the Togliatti Fiat plant is another example of this failure to recoup an investment in Western technology. The Soviets anticipated that part of the cost of the automobile plant would be offset by exporting the cars. In 1982, the Soviets

did export a total of about 110,000 automobiles to the hard-currency world, which brought them approximately $250 million. But since the Soviets were forced to sell their cars at about 75 percent of the cost of higher-quality Western models, their profit margin must have been very narrow.



Given the size of their country and their egos, Soviet planners tend to overscale many construction projects. The Baikal Amur Mainline Railroad in Siberia is one example of this costly "gigantomania."

Flaws in the Soviet Economic System

The main reason imported technology performs below expectations in the Eastern Bloc is because it was designed for economies where scarcity is the governing principle. If something is scarce, it is usually well-maintained and protected. Such equipment tends not to function as well when transported to a socialist economy, where the abolition of scarcity has been mandated by ideology but unfortunately not by fact. If scarcity is not a concern, then there is no special need to worry about how machinery or raw materials are treated. As a result, maintenance is poor, waste is endemic, and parts are cannibalized for use elsewhere. Machinery is generally utilized in a careless way. Not surprisingly, Western businesspeople report that the Soviets tend to use 50 to 70 percent more workers to operate equipment than factories in Western Europe. The absence of competition is also a factor. Since there is no need to outproduce a rival manufacturer, there is less need to worry about whether imported equipment is operating at its full potential. As a result, Western equipment sold to the Soviet Union tends to be only about two-thirds as productive as identical equipment installed in Western Europe.

Productivity levels could undoubtedly be higher if the Soviets allowed greater interaction with Western suppliers. Most East European countries, for example, now allow capitalist corporations to own a minority share in manufacturing enterprises. The Soviets, however, have fiercely resisted any temptation to bring in capitalist partners. Moreover, they often deny Western suppliers access to equipment once it is installed in Soviet territory. In some cases Westerners have been asked to make bids on factories to be installed in the Soviet Union and then have not been given access to the site until long after construction was under way. These restrictions reflect Soviet embarrassment over the paucity of guest accommodations, as well as the Soviet mania for secrecy. As a result, it becomes impossible to instruct the Soviets in operating and servicing such equipment, or to draw up appropriate designs for the new factories. Without access to ongoing service from the manufacturer, it is not surprising that productivity of equipment in the Soviet Union is so often lower than in comparable installations elsewhere.

Even when imported technology is installed and producing as anticipated, it may still be inefficient. This is because the Soviets tend to overscale many projects, particularly imported ones. Western observers call this gigantomania. Given the size of their country and their egos, Soviet planners tend to feel that if what they construct is not the largest operation in the world, it reflects badly on Soviet economic prowess. Thus, the construction process can devour massive quantities of resources, including capital and hard currency that could and often should be used elsewhere. Large projects such as the Kama River diesel truck plant at Brezhnev, the metallurgical complex at Kursk, and the BAM (Baikal Amur Mainline) Railroad across Siberia are very costly. Soviet planners have difficulty comprehending that when large quantities of resources are allocated to priority projects, they are not available elsewhere. Thus, when the Kursk metallurgical complex, already several years overdue, is finally com-

pleted, it may well increase Soviet output of high-grade steel. But in the meantime, the Soviet Union will have gone without the increased steel output that could have come from modernizing existing mills.

The lack of incentives in the Soviet economic system also impedes efforts to reproduce imported technology for use elsewhere in the Soviet Union. According to Western businesspeople who supply equipment to the Soviet Union, Soviet chemical firms have not been able to copy imported equipment on a large scale. While the Soviets can produce spare parts for some of the plants, the industry tends to fall back on Western suppliers when new plants are needed. There has also been little diffusion of technologies purchased for the Moskvich automobile plant in Moscow, which employed Renault technology, and the Kama River diesel truck plant. Instead, other auto manufacturers in the Soviet Union simply buy similar technologies from the same Western suppliers.

Far Behind in High Technology

If the Soviets remain unable to generate their own technology, and if they continue to have such mixed results with imported technology, how will they catch up to Western Europe and the United States—particularly when those countries are trying so desperately themselves to outperform the Japanese? At a time when most developed countries are competing fiercely to gain an edge in new high-technology markets, the Soviets are still turning to the West for their steel and aluminum mills. Only belatedly are they beginning to concern themselves with the explosion of microchip-based information technology. Hand calculators are just becoming available in the Soviet Union, and digital watches were invented there about two years ago. The system of central planning, and the Soviet emphasis on quantity rather than quality or innovation, has proven unequal to the task of coping with these fast-breaking civilian technologies. The Soviets remain small-time players in the international sweepstakes of high technology.

Given these difficulties, it seems somewhat paradoxical that we devote so much attention to controlling the flow of technology to the Soviet Union while concerning ourselves so little with technology transfer to countries such as Japan and now Taiwan and Korea. These newly industrialized countries often take the equipment that we sell them, adapt it, and send it back to us in the form of a competitive product within a few years' time. These countries use imported technology far more efficiently than the Soviet Union.

A decade ago, we were beseiged with warnings about how the Soviet Union might disrupt world markets by dumping vast quantities of cheaply made machinery produced with Western equipment. So far, the Soviets have had great difficulty exporting any machinery to the hard-currency world. The fact that over 83 percent of Soviet exports (other than armaments) to the capitalist world consists of raw materials hardly conveys an image of the world's second largest industrial power. Except for automobiles and some tractors and hydroelectric equipment, the Soviets have little to offer those in the market for industrial products.

Of course, the concern about technology transfer to the Soviet Union relates more to military results than to economic results. Yet most of what the Soviet Union obtains for its military needs is acquired through espionage or other illicit methods. Such technology is hidden away in a suitcase or a diplomatic pouch (as in the case of transistors), sent via other parties to "neutral" third countries (computers), or stolen (documentation on U.S. satellites made by TRW). The stricter customs inspections recently imposed by the United States under its Operation Exodus program may reduce this flow, but cutting it off entirely may be impossible. Late last fall, U.S. customs officials intercepted two powerful computers that were being shipped illegally via Sweden to the Soviet Union. The computers, both Digital Equipment Co.'s VAX 11-782 models, are powerful enough to guide long-range missiles. Such shipments are prohibited by U.S. export regulations.

Given the fact that most of the technology the Soviet Union acquires for its military arsenal comes through illicit channels, we should be focusing our attention on plugging up these channels rather than restricting legitimate trade.

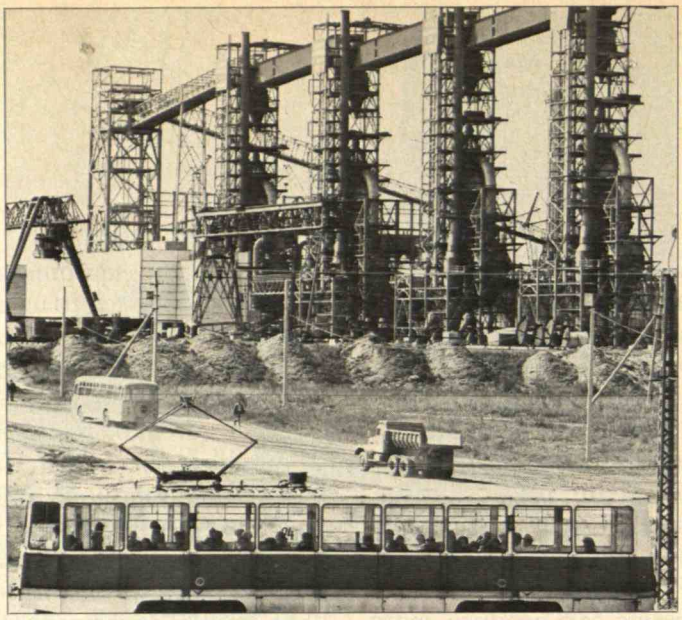
But no matter how vigilant we may be, the fact remains that our allies most likely will take a more relaxed attitude toward trade than we do. Trade as a percentage of GNP is considerably more important to our allies than to us, particularly in a recession. Last year, for instance, nearly 10 percent of West Germany's exports went to the Soviet Union and Eastern Europe. With some reason, the Europeans

and Japanese have warned that if we in the West tie ourselves up with too many restrictions on goods and knowledge, we may end up doing as much damage to one another as to the Soviet Union. Our emphasis should be on increasing the overall flow of technology and innovation to stay a generation or two ahead of Soviet technology.

Admittedly, Western Europeans sometimes appear so eager to sell to the Soviet Union that it seems as if there is nothing the Soviets can do that might be cause for cutting off trade. The invasion of Afghanistan caused barely a ripple in international trade, and the declaration of martial law on the Europeans' very doorstep in Poland hardly provoked more than a stir. Therefore, we must be careful to cry "bear" only when the bear is there. Part of the resistance of the Europeans is due to the excessive paranoia they believe we sometimes exhibit toward the Soviet Union. Thus, when a real emergency arises they have trouble distinguishing it from false alarms.

In choosing to exercise control over exports, the United States runs the risk of losing out not only on sales to the Soviet Union but also on sales to third parties. Increasing numbers of European and Japanese manufacturers are designing their products to obviate the need for using American computers and licenses. They are fearful that the United States will prohibit them from selling to third countries, which is what happened to eight European companies in 1982. (*See "The Debate Over Export Controls," page 75.*)

Sometimes we behave just as irrationally when we attempt to restrict the activities of scientists and the flow of technical information. That does not mean that we should openly circulate top-secret reports in a specially translated Russian edition, or allow Russians access to our secret laboratories. However, there is a danger that in our effort to restrict Soviet access to technological information, we may also hamper our own research and innovation effort.



Although most developed countries are competing fiercely for new high-technology markets, the Soviets are still turning to the West for their steel mills. Built with imported technology, the enormous Kursk metallurgical complex is still under construction.

Despite the fact that imported technology is costly and often fails to perform efficiently, the Soviets and their allies will probably continue to rely on it. The Soviets, of course, would prefer to train their scientists, engineers, and managers to come up with their own innovations. But to do this, they would have to create a whole new system of managerial incentives. That, in turn, would require far-reaching reform of the Soviet economic system. Because the necessary changes would likely be traumatic, the prospects for meaningful reform are not good.

Thus, it is likely that the Soviets will continue to seek imported technology to help them modernize their economy. Some of this imported technology will no doubt increase the military strength of the communist bloc. But on the whole, this possibility seems much less threatening than some U.S. opponents of trade have argued. We must also remember that restrictions on such trade are not without cost. Not only do we lose export earnings, but attempts to enforce embargos generate considerable tension between us and our allies. Such battles are sometimes worth fighting, but we must select our targets carefully. The United States has often been too restrictive. As a result, we have often hurt ourselves and our relations with our allies as much as we have hurt the Soviet Union.

MARSHALL I. GOLDMAN is professor of economics at Wellesley College and associate director of the Russian Research Center at Harvard University. He is author of The U.S.S.R. in Crisis: The Failure of an Economic System *(W.W. Norton, 1983).*

Midgetman: The Questioning Starts

Midgetman, the small missile carrying only one warhead, is that rarest of birds, a popular ICBM. The Scowcroft Commission, appointed by President Reagan to study the nation's strategic nuclear defense, put the long-range security of the land-based missile force squarely on Midgetman, and that proposal has found wide support in Congress. "I don't know why we don't just skip the MX and go directly to the small missile," says Rep. Jim Bates (D-Calif.), who led an unsuccessful revolt in the House against the MX. Some congressional moderates even reluctantly supported procuring MXs in exchange for Reagan's commitment to develop the small missile. And Congress readily voted a quarter of a billion dollars for research and development on the Midgetman this year.

But the Midgetman is as nebulous as it is popular. "This missile is not a missile at this point, but a plan and a concept," Defense Secretary Casper Weinberger has pointed out. And most of the plans for the Midgetman call for either mobile missile launchers that have not been developed or arms-control agreements that have not been negotiated. In this the Midgetman does resemble the MX—a missile that was long promoted without any agreement on where to put it or what its role should be.

What Rationale?

Midgetman's main attraction lies in the two-for-one rule of nuclear strategy: to be reasonably confident of destroying any one missile, an attacker must drop two warheads on it. MIRVed missiles with multiple warheads are thus high-value targets: two Soviet warheads can destroy the 10 warheads of an MX, for example. Midgetman is an inherently low-value target: two Soviet warheads would be required to destroy only one Midgetman warhead. If Soviet and U.S. forces were composed of roughly equal numbers of single-warhead missiles, neither side could disarm the other with a first strike. The chance of nuclear war would therefore be reduced, as a result.

Six hundred tons of explosives went up last October 26 in a blast detonated by the Defense Nuclear Agency. Shapes for mobile launchers for the single-warhead Midgetman missile were tested.

That was what Rep. Albert Gore, Jr. (D-Tenn.), had in mind when he began pushing the small, single-warhead missile several years ago. Gore proposes basing about 500 U.S. and Soviet single-warhead missiles in hardened silos, while using arms-reduction agreements to eliminate or sharply reduce each side's MIRVed missiles. Thus, neither superpower could plausibly threaten the other's land-based missiles.

Gore may be the most prominent Midgetman supporter in Congress, but his allies are reluctant to rely on his basing scheme. Its success requires that the Soviets be willing to negotiate away their current advantage in MIRVed missiles. McGeorge Bundy, former adviser to President Kennedy on national-security issues and a prominent Midgetman supporter, spoke for many observers when he said, "If you can negotiate levels like Gore's, they're fine. But they're hard to negotiate."

To address the needs of a real—not an ideal—world, the Scowcroft Commission, joined by Rep. Les Aspin (D-Wisc.), recommended deploying the Midgetman missiles in some sort of mobile basing system such as trucks. This approach is in vogue at present, and several schemes for implementing it have been proposed.

John Glenn, presidential candidate and Democratic senator from Ohio, would truck the missiles around on public roads. "The Soviets cannot possibly target them all," he told several members of the Scowcroft Commission. But the commission, Aspin, and the Pentagon aren't enthusiastic about Glenn's idea. "Everyone agreed long ago that you can't put these things on I-95 to cruise around disguised as beer trucks," says Warren Nelson, an aide to Aspin. "They're not even talking about that in the air force any more. The security problems would just be too immense."

A Missile Reservation

The air force is working on another mobile deployment scheme for Midgetman. The missile carriers would be driven around on their own military reservation—perhaps half as large as the state of Rhode Island—somewhere in the Southwest. But this scheme shows signs of suffering some of the same problems of size, expense, and ineffectiveness that plagued the racetrack scheme proposed by the Carter administration for the MX. To begin with, if carriers just rambled around the reservation, security would be needed not only at the borders but throughout the interior.

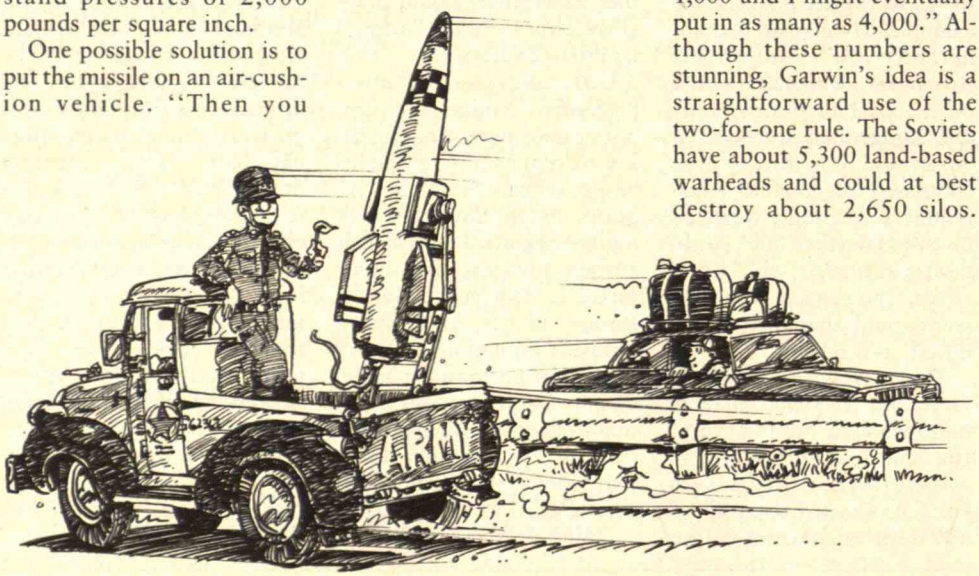
PHOTO: FRANK TREVINO, U.S. ARMY

To ease the security problem, the missiles could be parked in a small "staging" area within the reservation. On warning of an attack—presumably a barrage by Soviet land-based missiles—the mobile carriers would scramble fast and far. They wouldn't have long to get out from under the barrage. "I don't think anybody's decided on the exact number of minutes," says Nelson. "But we're talking about significantly less than 15 minutes."

Therefore the carriers would ideally be both very fast and very "blast resistant" to nearby bomb explosions. Unfortunately, these are incompatible traits. Greater blast resistance means greater weight, but greater weight slows the carriers down. Nobody knows just how resistant a mobile missile carrier could be. R. James Woolsey, a member of the Scowcroft Commission and special delegate to the START talks on strategic weapons, estimates that a typical mobile vehicle might resist a pressure of only 20 pounds per square inch from a blast. Immobile missile silos can be built to withstand pressures of 2,000 pounds per square inch.

One possible solution is to put the missile on an air-cushion vehicle. "Then you wouldn't have to worry about roads," says Nelson. "You could just send that thing sailing out over somebody's cornfield. If you could get an air-cushion vehicle heading out of there at 80 miles an hour, you could probably make do with a blast resistance of 8 or 10 pounds per square inch." But novel technologies would be required for such immense air-cushion vehicles. (No one knows just how large mobile launchers would have to be. But it's a measure of their size that keeping wheeled carriers lighter than 85,000 pounds, the legal limit on federal roads, may be difficult.)

Whatever the design of the mobile force, some proportion would be destroyed by a Soviet barrage. Woolsey posits that only 30 to 50 percent of the missiles would survive, but he argues that that would be good enough. Even if large numbers were deployed, he says, roughly the same percentage would survive. Thus, the Pentagon could simply decide how many missiles it would need after an attack, and then build two or three times that number.



Could the Soviets simply send enough warheads to swamp any conceivable mobile system? Woolsey thinks that might be suicidal. "I don't know if anybody *knows*," he says. "But there are at least estimates that attacks of that size would be self-defeating. I don't know whether the study done by Carl Sagan and his friends is right about nuclear winter, but at some point you produce enough upper-atmosphere fallout to create serious problems for the whole Northern Hemisphere."

Wary Optimism

One basing scheme purports to strike a strategic balance without arms-control agreements or novel technologies. This scheme is not being pursued by anyone in government but by Richard Garwin, an IBM fellow and prominent defense analyst. He would build thickets of Midgetmen in silos. "To save operating costs and use the same command-and-control network, I would put the Midgetmen into the Minuteman fields. I would start by putting in 1,000 and I might eventually put in as many as 4,000." Although these numbers are stunning, Garwin's idea is a straightforward use of the two-for-one rule. The Soviets have about 5,300 land-based warheads and could at best destroy about 2,650 silos. Garwin's plan would provide for a deterrent force of some 1,500 Midgetmen after the Soviets had done their worst.

If the Soviets responded by building more heavy MIRVed weapons, would that cost them more than the United States would have to pay to respond with additional Midgetmen? Garwin's analysis shows that Midgetmen in silos probably cost more than the least expensive warheads that could be deployed on MIRVed missiles, but are much cheaper than the MIRVed systems that are actually proposed. Many people disagree. Woolsey points out that the Midgetmen would require 10 times as many electronic guidance packages as MXs carrying 10 warheads. Garwin responds that guidance systems produced efficiently, in large quantities, would drop in price and be "lost in the noise" of other costs. Furthermore, the alternative to Garwin's scheme—the proposed mobile systems—are hardly inexpensive. A mobile launcher may cost 20 or 30 times as much as a silo, Nelson says.

Whatever its merits, the Midgetman is going to be with us for some time. The last round of attempts to find a missile a home, any home, led to the racetrack and dense-pack schemes for the MX—schemes all but universally condemned as harebrained. Against that background, it's noteworthy that Midgetman supporters, unlike the earlier MX supporters, are evincing a certain caution. Woolsey, for one, contends that "with the right kind of arms-control agreements, and especially work on the hardened mobile launcher, there are some potentially positive trends. I think that's the most one can say."—*David Kennedy* □

ILLUSTRATION: JON McINTOSH

In a 10-mile-per-hour test crash performed by the Insurance Institute for Highway Safety, a 1982 Honda Accord received less than $600 worth of damage. But after federal regulations were relaxed, many automakers installed weaker bumpers on 1983 models. A 1983 Accord had $1,400 worth of damage in a similar test crash.

Bumper Strength: Will Deregulation Pay?

Shortly after entering office, the Reagan administration trumpeted a number of ideas for reviving Detroit in a booklet titled "Actions to Help the U.S. Auto Industry." One of these was an example of the administration's penchant for cutting regulation: a proposal that automobile bumpers should no longer be required to withstand 5-mile-per-hour collisions. Sure enough, in May 1982 the National Highway Traffic Safety Administration (NHTSA) decided that henceforth bumpers would have to be strong enough only to withstand 2.5-mile-per-hour collisions.

But now the General Services Administration, the government's own purchasing agent, has decided to buy only car models that manufacturers are voluntarily equipping with the stronger bumpers. This proves that the government itself thinks the 5-mile-per-hour bumpers are more economical in the long run, according to Allstate and State Farm Mutual insurance companies. They are challenging the weaker bumper standard in federal court in Washington, D.C.

NHTSA first issued its 5-mile-per-hour bumper standard in 1972, primarily on safety rather than economic grounds. The agency concluded that minimizing the damage to headlights, gas tank, and other safety-related equipment in a car's first accident would help the driver avoid a second accident down the road. The standard required that neither cars nor bumpers be damaged in a 5-mile-per-hour crash.

Engineered Bumpers

Over the next decade, rigidly mounted steel bumpers gave way to aluminum bumpers mounted on shock absorbers, which could cushion the impact of a crash yet remain unharmed.

But debate continued over the bumper regulations. Not long after the original 1972 standard was promulgated, Congress passed a law requiring NHTSA to take cost as well as safety into account. Thus, agency analysts had to balance the lower purchase price of a 2.5-mile-per-hour bumper, and the fuel savings owing to its lighter weight, against the higher accident repair bills and insurance premiums that might result. A lack of reliable data, together with the inherent complexity of this economic balancing act, caused controversy over the 5-mile-per-hour and 2.5-mile-per-hour bumpers.

The auto industry supported the lower standard, claiming it would reduce sticker prices, but insurance and consumer groups insisted that the higher standard would save money in the long run. Finally, after a good deal of indecision in the Ford and Carter administrations, Reagan's NHSTA lowered the standard, and automakers began cutting back. Detroit installed 5-mph bumpers on about half its 1983 cars, and fewer 1984 models will have them, according to Clarence M. Ditlow III, director of the Center for Auto Safety.

The new 2.5-mile-per-hour standard allows the bumper itself to be damaged. Thus, the regulation can be met with old-fashioned rigidly mounted bumpers, according to Brian O'Neill, senior vice-president of the Insurance Institute for Highway Safety. "The difference between the two standards is in whether you use engineering principles to absorb the energy of a crash or sheet metal that is crumpled and bent," says O'Neill.

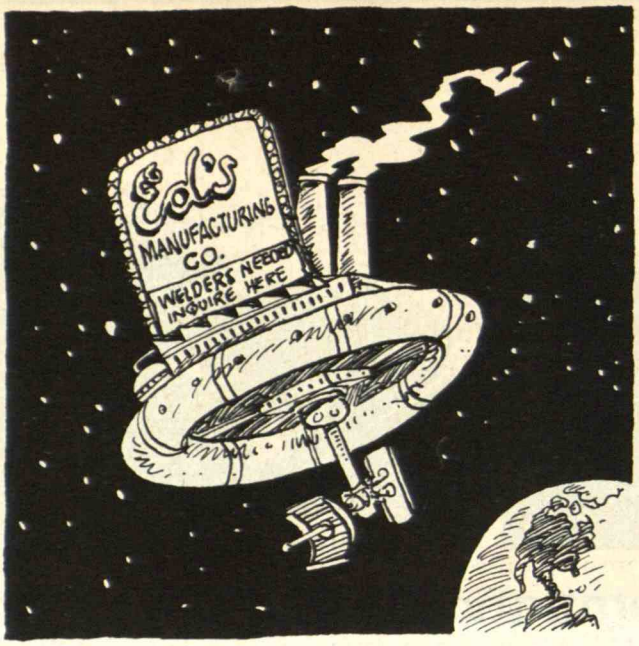
The chief basis for the Reagan administration's move was a Ford Motor Co. study. By counting dents on cars in parking lots, researchers deduced that low-speed accidents were far less common than previously thought. But O'Neill has no use for these data, charging that "NHSTA's numbers were pulled out of thin air." The Highway Loss Data Institute says the damage estimates that NHTSA relied on in reducing the bumper standard could be off by a factor of five.

The Real Cost

Since the rule was changed, no auto manufacturer has claimed a price drop owing to less sophisticated bumpers. But insurance companies say that accident data show a correlation between 2.5-mile-per-hour bumpers and bigger claims, and some insurance rates have gone up as a result. State Farm predicted that the 2.5-mile-per-hour bumpers would eventually cost motorists about $10 a year in insurance premiums.

State Farm and Allstate, together with the Center for Auto Safety, have asked the federal appeals court to instruct NHTSA to return to the tougher standard. A decision will come soon.—*Deborah Baldwin* □

PHOTOS: INSURANCE INSTITUTE FOR HIGHWAY SAFETY



Space Entrepreneurs

How best to promote entrepreneurs' ideas for doing business in space? Hold a conference, concluded venturist Donn Walklet. Walklet's firm, Terra-Mar, packages and sells "remote-sensing" data gathered by government satellites on subjects such as world agricultural conditions and fossil-fuel reserves. His conference in New York last fall attracted a collection of like-thinking entrepreneurs with plans to manufacture products in space, and even to sponsor launch vehicles.

Commercial Launches

The entrepreneurs' enthusiasm about their own projects is hardly a surprise. Perhaps more unexpected is the fact that the presumably wary financiers of Wall Street are showing genuine interest in backing some of these projects with hard cash. "We're looking for opportunities for investment," says Fran Finnegan, a venture-capital specialist from E.F. Hutton.

The most adventurous project proposals come from firms such as Pacific American Launch Systems and Starstruck, which want to send up launch vehicles by the end of the decade to compete with NASA's. The NASA shuttle cost $16 billion to develop. However, Gary Hudson, president of Pacific American, is planning to build a smaller version that he says would probably cost between $100 million and $500 million. Pacific American has not yet found financial backing.

Some entrepreneurs resent NASA for leasing space on its shuttle at artificially low prices; private concerns can now send small payloads into orbit on the shuttle for only thousands of dollars. "NASA is competing with the private sector instead of just doing basic research that industry can turn into a product," Walket maintains. "Products can be sold and generate taxes for the government. When going into space gets to be as conventional as flying aircraft, it should be turned over to the private sector."

But the entrepreneurs who want to build launch vehicles face a big financial challenge. The initial space investors are likely to be venture capitalists, who have only several million dollars—not several hundred million—at their disposal. "No one venture-capital firm or consortium will ever come up with enough capital to build a launch vehicle," says Jonathan Conrad, principal with the Sconset Group, investment bankers. He feels that entrepreneurs planning to launch vehicles into space have their expectations "a little high." "Huge companies can afford to sink money into launch vehicles," says Finnegan. "At least in the early stages, it is they who will handle the transportation and the smaller firms who will use it for manufacturing." One large company, the Convair division of General Dynamics, has a project underway to use its Atlas-Centaur rocket commercially.

Large-scale space manufacturing requires expensive orbital stations as well as launch vehicles. If President Reagan approves the plan, NASA will spend between $7 billion and $10 billion to build a prototype space station by 1991. Meanwhile, NASA is collaborating with Fairchild Industries to put unmanned space platforms, called Leasecraft, into orbit by 1987. Fairchild reports that a number of prospective customers have already expressed interest.

Products That Pay

The only industry currently operating in space is communications. Beaming signals from place to place is a billion-dollar business for satellite-owning companies such as AT&T, RCA, and Western Union. The government also does a thriving trade in information gathered with remote-sensing equipment.

Any product manufactured in space must sell for a price high enough to amortize the colossal cost of making it. For example, Microgravity Research Associates (MRA), a three-year-old entrepreneurial firm, has signed a joint-venture agreement with NASA to produce gallium arsenide and other super-efficient semiconductor materials for electronic components. High-quality gallium arsenide is almost impossible to produce on Earth because of the effects of gravity. NASA will provide technical assistance and free shuttle flights during the development stage, and the company will assume all expenses once large-scale manufacturing begins. MRA estimates that these semiconductor materials will have to sell for about $1 million per kilogram as long as manufacturing is done on the shuttle. MRA expects the price to drop when orbital stations can be used for manufacturing—to about $500,000 per kilogram in the early nineties and $300,000 per kilogram in the late nineties.

McDonnell-Douglas, the aerospace conglomerate, has signed a similar agreement with NASA to make pharmaceuticals. Producing some drugs, worth up to $22 million per pound, in space increases the yield and reduces the chance of contamination. McDonnell-Douglas' experiments have so far focused on producing hormones from cells. But the real bonanza is expected to be in making interferon. Interferon may be used by as many as 20 million patients a year to treat cancer and immunize against viral infections, according to Rockwell International, one of the prospective contractors for the NASA space station.

Firms that manufacture products in space are going to have to learn not only how to

ILLUSTRATION: JON McINTOSH

manage the space business but how to manage it efficiently—a new skill for the aerospace industry. That sector has traditionally been dominated by large conglomerates working exclusively on defense and other government contracts without a fixed budget. "Government bids don't go for efficiency," says Conrad. "In fact, a government contractor makes more money by being large and inefficient. So entrepreneurship doesn't come naturally to aerospace. But this can change. Therein lies the challenge."—*Diana ben-Aaron* □

Classroom Technology

To solve the crisis in high-school science education, Professor Morris H. Shamos of New York University suggests teaching not science itself but technology. Although high-school students have traditionally been taught pure science, Shamos argues that it is too abstract to interest most of them—and perhaps their teachers, too. Teenagers generally don't want or need to know about solution temperatures, neutrinos, or the mechanics of solids. Their daily contact with science is through its products—technology.

"Instead of seeking to develop widespread literacy in science, if we were to focus our attention on technology, we would be more likely to develop some understanding of both," Shamos told the National Science Teachers Association (NSTA).

The emphasis on abstract science in high-school classrooms gained a boost with the post-*Sputnik* initiatives of the 1960s. The results have been very good for the best students: top engineering and science schools have found their entering classes better and better prepared. However, this theoretical approach—typified by the curriculum of the Physical Science Study Committee (PSSC) formed at M.I.T. in 1963—is making science inaccessible to as many as three-quarters of today's high-school students, say John W. Renner, professor of physics and science education at the University of Oklahoma, and Anton E. Lawson, professor of biology at Purdue. Like Shamos, they advocate teaching science more concretely—such as in terms of how ordinary refrigerators or televisions really work.

For nonscience students, the teacher's "primary objective should be to make them feel comfortable with their surroundings," Shamos told the NSTA. Education should help students understand enough about the workings of modern technology "to have a sense of being in control—to know the capabilities and limitations, and to appreciate the dangers."

Shamos suggests that schools continue to offer intensive physics, chemistry, and mathematics courses, taught by well-qualified teachers, for the roughly 10 percent of the students interested in scientific careers. Other students, even those preparing for college, should be given an understanding of science in action—technology.

But while science education may be moving toward technology, technology education is moving a little toward science. It's not that teachers in the American Industrial Arts Associaton (AIAA) have any intention of abandoning their role of preparing students for vocations such as automobile repair and metalworking. But often students learn about the nuts and bolts of technology and fall short of gaining a theoretical basis for their work.

At its 1983 convention, according to *Education Week*, the AIAA presented a three-year plan to help vocational-school teachers learn more physics, chemistry, and algebra. The teachers will then be qualified to give what AIAA thinks their students will increasingly need: a better ability to handle tools and materials based on a surer understanding of the underlying science.—*John Mattill* □

High school science students need more technology, and vocational students (such as this one in Dallas) need more science, say educators.

Burning Wastes at Sea

A storm is brewing over burning hazardous wastes at sea. The U.S. Environmental Protection Agency (EPA) is proposing to grant a permit to the *Vulcanus I* and *II*, two incinerator ships owned by Waste Management, Inc., to burn wastes containing toxic DDT and PCBs in the Gulf of Mexico. The burns are opposed by Greenpeace U.S.A., the Sierra Club, and the states of Texas and Louisiana. But it's a measure of the controversial nature of ocean incineration that in hearings in November, the National Wildlife Federation broke ranks with its fellow environmental groups and, on balance, favored the permit.

The question of whether to issue this permit is merely a particular case in the general debate over ocean incineration. The issue arose in 1972 when a Dutch company, Ocean Combustion Services, B.V., retrofitted a cargo ship with a furnace to burn hazardous wastes and named it *Vulcanus* after the Roman god of fire. Because the ship can travel to any port, hazardous wastes, which are often explosive, do not have to be transported long distances by land. The burning poses few dangers to people other than the crew because it takes place far from population centers.

Perhaps most significant, incineration at sea costs about two-thirds as much as on land, the EPA estimates. The saving occurs largely because scrubbers that remove poisonous emissions of hydrogen chloride are required on land but not at sea. The theory is that the hydrogen chloride turns to hydrochloric acid on the surface of the water and is neutralized by the alkaline sea environment.

The *Vulcanus* has burned hazardous waste frequently in the North Sea and five times in U.S. waters. The first three times it burned organochlorine waste from Shell Oil refineries and Agent Orange left over from the Vietnam War.

Continued on page 87

PHOTO: CARY WOLINSKY, STOCK BOSTON

Scientific Literacy and Universal Service

There are three imperatives for educational change in the U.S., David S. Saxon, chairman of the M.I.T. Corporation, told the National Association of State Universities and Land-Grant Colleges.

□ Give students better ability to cope with the rapid changes that technology has brought and will bring. This means achieving "scientific literacy" for all students: "No educated person can afford to be ignorant of the character and limits of science," said Dr. Saxon, "and no person ignorant of the character and limits of science can be called educated." Furthermore, he said, for students entering technical fields, today's institutions must provide "a truly fundamental base of knowledge" on which they can build through lifelong education.

□ Provide the wide access to higher education for all citizens that was the vision when the land-grant colleges were founded. "We have fallen far short" of the goal to make education open to all "on the basis of ability and talent alone," Dr. Saxon said. "To be poor, to be a woman, to be a member of a racial minority has often blocked the way."

□ Couple education closely to national needs—another precept of the land-grant college movement. To this end, Dr. Saxon suggested a blue-ribbon study of universal youth service coupled with a universal "G.I. bill" for education. Young people would undertake socially valuable activities (including military service) at national, state, and local levels—and having done so would be assured of access to a university or technical education. All students would thus share "a greater sense of identification with and responsibility for the national welfare," Dr. Saxon said.□

Fusion Record

The fuel density and confinement time necessary for producing energy in a fusion reactor were achieved at M.I.T. on November 3 for the first time anywhere in the United States.

The combination of density and confinement level reached in the Alcator C reactor was "about a factor of two larger" than in any previous experiment, said Ronald C. Davidson and Ronald R. Parker at an American Physical Society meeting in Los Angeles. The new values "exceed for the first time the minimum required for fusion energy breakeven."

The report came as Davidson and Parker—and three other members of the M.I.T. Plasma Fusion Center—were honored with the APS' first-ever Award for Excellence in Plasma Physics. Two major advances, which led to the new density-confinement record, were cited:

□ The discovery that plasma energy confinement in a tokamak increases as plasma density increases.

□ The achievement, using this new relationship (which was not predicted by theory), of a world record in 1980 for plasma confinement in the Alcator A.

Alcator C's record was set with a temperature of about 17 million degrees Celsius and a confinement time of 50 milliseconds.□

Motion Sickness: An Early Report from Spacelab I

Returning home from their vigil at NASA headquarters in Houston, Professor Laurence R. Young and other M.I.T. scientists involved in experiments on space motion sickness aboard Spacelab I described the mission with highest enthusiasm: "An enormous scientific success that far exceeded most of our expectations."

"That success is due at least in part to the fact that the two scientists on the mission were able to work innovatively," said Young. They were "essentially a branch of our investigation in space."

One of the two was Byron K. Lichtenberg of Young's M.I.T. research team.

Young said his team was finding "some very interesting alterations in the way visual information is interpreted in space in comparison to on Earth. We were able to demonstrate early in the flight the value of tactile clues," said Young. But later the astronauts seemed to be much less dependent on these.□

Continued from page 85

In 1980 Waste Management bought the *Vulcanus* from its Dutch owners and received permits from the EPA to burn wastes laden with PCBs in the Gulf of Mexico, once in 1981 and once in 1982. In 1982 Waste Management commissioned a new ship, *Vulcanus II*, that is now in service on the North Sea.

The EPA has not yet established permanent regulations for ocean incineration, despite promises to do so. Instead, the agency is issuing special permits case by case. Hence the debate over a permit for the burn proposed for this spring.

Keeping Them Honest

One of the problems with the *Vulcanus* is the credibility of its owners. Waste Management is being investigated by federal and state authorities for alleged illegal dumping at seven of its landfills throughout the country. Critics wonder how careful the company will be in monitoring incineration when the *Vulcanus I* and *II* are over 200 miles from land, far from the watchful eye of a regulator on a surprise visit.

Ocean incineration requires especially close monitoring for technological reasons. The principle of land or sea incineration is the same: if you keep hazardous wastes long enough in a hot enough place, and make sure that they're sufficiently mixed in the combustion chamber, they will degrade to largely innocuous matter. However, it is harder in the cramped quarters on a rolling sea than on land to guarantee the crucial temperature, duration, and turbulence.

Supporters of ocean incineration point to tests performed by TRW Associates showing that the two recent *Vulcanus* burns met EPA requirements. In the 1981 burn the combustion efficiency was rated at 99.96 percent, and in the 1982 burn the efficiency was measured as 99.99 percent, thus meeting the requirements for land incineration.

However, TRW didn't test for particulates (soot), as pointed out by critics such as Edward W. Kleppinger, a member of the Hazardous Waste Treatment Council representing land-based disposal companies. TRW argued that at the high temperatures of the burns, particulates wouldn't be formed, so there was no need to test for them. But if something goes wrong and combustion is incomplete, particulates even more toxic than the original waste can be released. It is for this eventuality that critics oppose cutting the costs of ocean incineration by not requiring scrubbers at sea.

Michael Connor, a research fellow at the Harvard School of Public Health, is concerned that if PCBs are not adequately destroyed, they could harm shrimp and other environmentally sensitive fish in the Gulf of Mexico. People take in PCBs principally by eating fish. Kleppinger also wonders what would happen if there were a disaster such as the explosion that occurred in a land-based incinerator operated by Rollins Environmental Services in New Jersey. A disaster at sea would take place far from people—other than the crew—but the spilled wastes could not be cleaned up.

Federal Subsidies

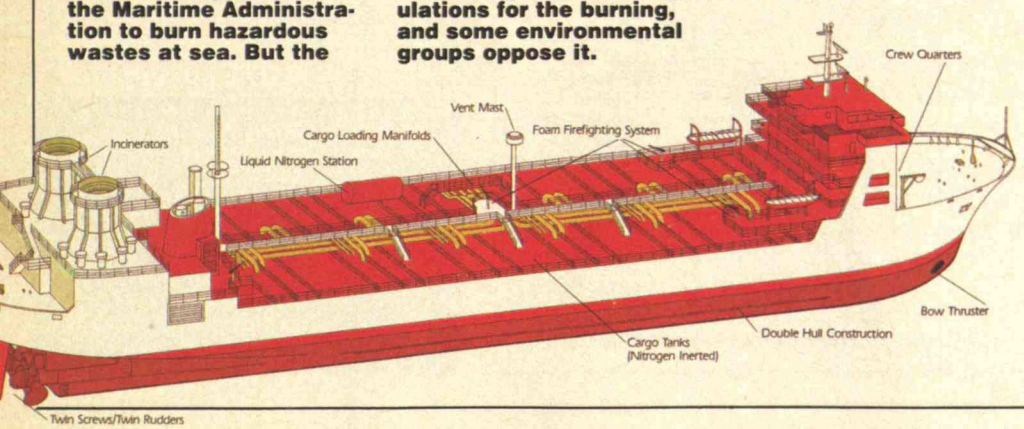
Despite such questions, the federal government is supporting a new generation of ocean-incineration vessels. In 1982 the Interagency Review Board for the Chemical Waste Incinerator Ship Program, composed of representatives from several federal agencies, recommended that the government help finance ocean incineration. In April 1982 the Maritime Administration guaranteed a loan of $55 million to At-Sea Incineration to construct two incineration ships.

That company's furnaces use an "atomizing nozzle"—a kind of fine shower spray—to disperse the wastes into the furnace. According to incineration engineers, this produces finer droplets, and hence more complete burning, than the "rotary cup" on *Vulcanus I* and *II*, which breaks the waste into droplets by a whirling motion. Also, twin engines will allow the ships owned by At-Sea Incineration to negotiate busy harbors with precision, and their waste tanks are separated into 12 compartments so that an accidental spill could be contained.

Incineration is probably more efficient on land than on sea, but these are hardly the only options. According to a March 1983 report by the congressional Office of Technology Assessment, at least 80 percent of the hazardous waste produced in the United States not destroyed at all, but is disposed of on land. This waste can be held in lagoons, injected into the ground in dry areas, or stored in landfills. However, as Joel Hirschhorn, principal author of the report, points out, "All land disposal methods will eventually fail. The only question is when." If one considers the dangers of such methods of hazardous-waste disposal—not to mention illegal dumping—then arguing over minute toxic particulates 200 miles out at sea may seem like fiddling while Rome burns.

—Robert Barnett □

The *Apollo*, owned by At-Sea Incineration, was built with support from the Maritime Administration to burn hazardous wastes at sea. But the U.S. Environmental Protection Agency has yet to establish permanent regulations for the burning, and some environmental groups oppose it.



CLASSIFIEDS

PROFESSIONAL

You're Boxed In

Your career is blocked. You're frustrated and insecure. Time is going by and things aren't getting better.

You need to find a better way. You need new objectives for yourself and new strategies for achieving your objectives.

That's my job. I am a management consultant, specializing in change, and I have helped hundreds get out of that box and onto a more satisfying career and life path.

Call me to explore what I can do for you. There's no charge, no obligation, to explore. Don't wait. Call me now.

Riva Poor, SM Management, MCP from MIT

Private programs. Also 2-day weekend workshops. *(See p. 7 for details.)*

Riva Poor
73 Kirkland Street
Cambridge, MA 02138
Telephone: (617) 868-4447

THE ACCESS GROUP, INC. — **Engineering Specialists Nationwide**

All Levels-All Industries.
ALL FEE PAID-FULLY CONFIDENTIAL.
Contact-Bill Kan, Ph.D. '58,
P.O. Box 3267
Stamford, Ct. 06905. 203-356-1166

THE BEST & BRIGHTEST

Ask P'nB to Market Them Because I'm an Engineer Who Talks Your Language

Was out there myself for 25 years—from Designer to Program Manager.
An IEEE member and MIT engineer, I know what YOU want.
Send your resume, you'll be the client, with all fees and expenses paid by nationwide companies looking for the BEST and the BRIGHTEST

Marc Cutler, President
(215) 687-4056 day or night

P'nB CONSULTANTS
Box 494-T, Wayne, PA 19087
Known Coast to Coast

MATH & SCIENCE OPENINGS

Leading private schools seek teachers for positions in all science fields. Selected referrals for qualified candidates. For information call:

SANDOE ASSOCIATES
In Boston (617)262-5380
or toll free (800)225-7986

NELSON, COULSON AND ASSOCIATES, INC.
Consulting Engineers

COLORADO OPPORTUNITIES

- Ph.D. Consultant: strong satellite systems background. Excellent salary, benefits and relocation!
- Aerospace Systems Engineers
- Computer Professionals
- Guidance & Controls
- RF/Microwave
- Space Communications C^3

For these and other positions, contact:

P. R. Coulson, PE, '43
NELSON, COULSON & ASSOC.
P.O. Box 1378
Englewood, CO 80150
303/761-7680

PLACING PROFESSIONALS COAST TO COAST

We are constantly searching for:
•Engineers: EE's, ME's, CHE's•
•Scientists•
•Computer Professionals•
•MBA's•
•Financial Specialists•

Submit your resume and salary history to:
MARTIN LYONS
PERSONNEL SERVICES, INC.
230 No. Main St.
Mansfield, MA 02048
(617) 339-9301

The High-Tech People

BINDERS

IDEAS WORTH SAVING

Save and protect your copies of TECHNOLOGY REVIEW in custom-designed library cases or binders. In simulated maroon leather with gold embossing. Case–$5.95 each. Binder–$7.50 each. Send check to: Jesse Jones Industries (Since 1843), P.O. Box 5120, Dept. TECR, Philadelphia, PA 19141. Allow 6 weeks for delivery.

PUBLICATIONS

ORDER NOW! GET COPIES EARLY!
"low sky, HIGH SKY" **$9.95* Postpaid**
Max Daggett's memorable aviation "story different".
*Pre-publication price expires 1/84. Check or money order: TX res. add 5%
PRIORITY PRESS
P.O. Box 30152 Dallas, TX 75230

NEW
From Technology Review—

Current, accurate information on today's important issues. Reprints of:

"Measuring the Intangible in Productivity," by Michael Packer

"Computer Crime," by Leslie Ball

are now available. Send $2.50 per copy plus $1.00 for postage and handling to Reprints, Technology Review, MIT 10-140, Cambridge, MA 02139

TRAVEL

SAIL VACATIONS

60' SCHOONER, 4 equal doubles, luxurious, Captain, Gourmet Cook and mate. Sail Caribbean/ New England. Reserve a cabin or charter entire yacht. **CAL 39',** tri-cabin, captained/bareboat Virgin Islands. Call/write, brochures, rates. Richard Durgan, Crimson Travel, 39 JFK St., Cambridge, MA. (617) 868-2600

VISITOR ACCOMMODATIONS

BED & BREAKFAST
CAMBRIDGE & GREATER BOSTON
HUNDREDS OF HOMES
LOW IN COST — HIGH IN HOSPITALITY
617-576-1492
DISCOVER HOW NICE WE CAN BE!
(VACATION HOMES, TOO) RIVA POOR, DIRECTORESS

CLASSIFIED ADS: $10.00 per line, three-line minimum. (Allow 28 letters & spaces for first line, 50 letters & spaces for each additional line.)
DISPLAY ADS: $50.00 per inch, 3-inch maximum.
COPY DEADLINE: Five weeks prior to publication date. Payment in advance of insertion required. Send orders to Classified Section, Technology Review, MIT 10-140, Cambridge, Mass. 02139.

A carat or more.
Because you were never very good at fractions.

Your jeweler can show you many diamond solitaires of a carat or more. This necklace features a 1.14 carat diamond.

A carat or more–one in a million.

Every diamond is rare.
But of all diamonds found, a solitaire of a carat or more is only one in a million.

And, like love, becomes more precious with time.

A miracle among miracles.
Born from the earth. Reborn on a woman.

The extraordinary diamond of a carat or more.

Show the world you couldn't have made it without her.

A diamond is forever. De Beers

CIMARRON '84
THIS ONE'S GOT THE TOUCH.

The Cadillac touch. It's Electronic Fuel Injection, matched by a tenacious Touring Suspension that comes to grips with the road. It's leather-faced front bucket seats with lumbar support behind a leather-trimmed steering wheel that lets you know you're in control. It's new grille and taillight styling. Laser-accurate quality fits. It's Cimarron '84...with something no other car in its class has. The Cadillac touch.

BEST OF ALL...IT'S A CADILLAC.

Let's Get It Together...Buckle Up.